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JOHN F. KELLY, EDITOR

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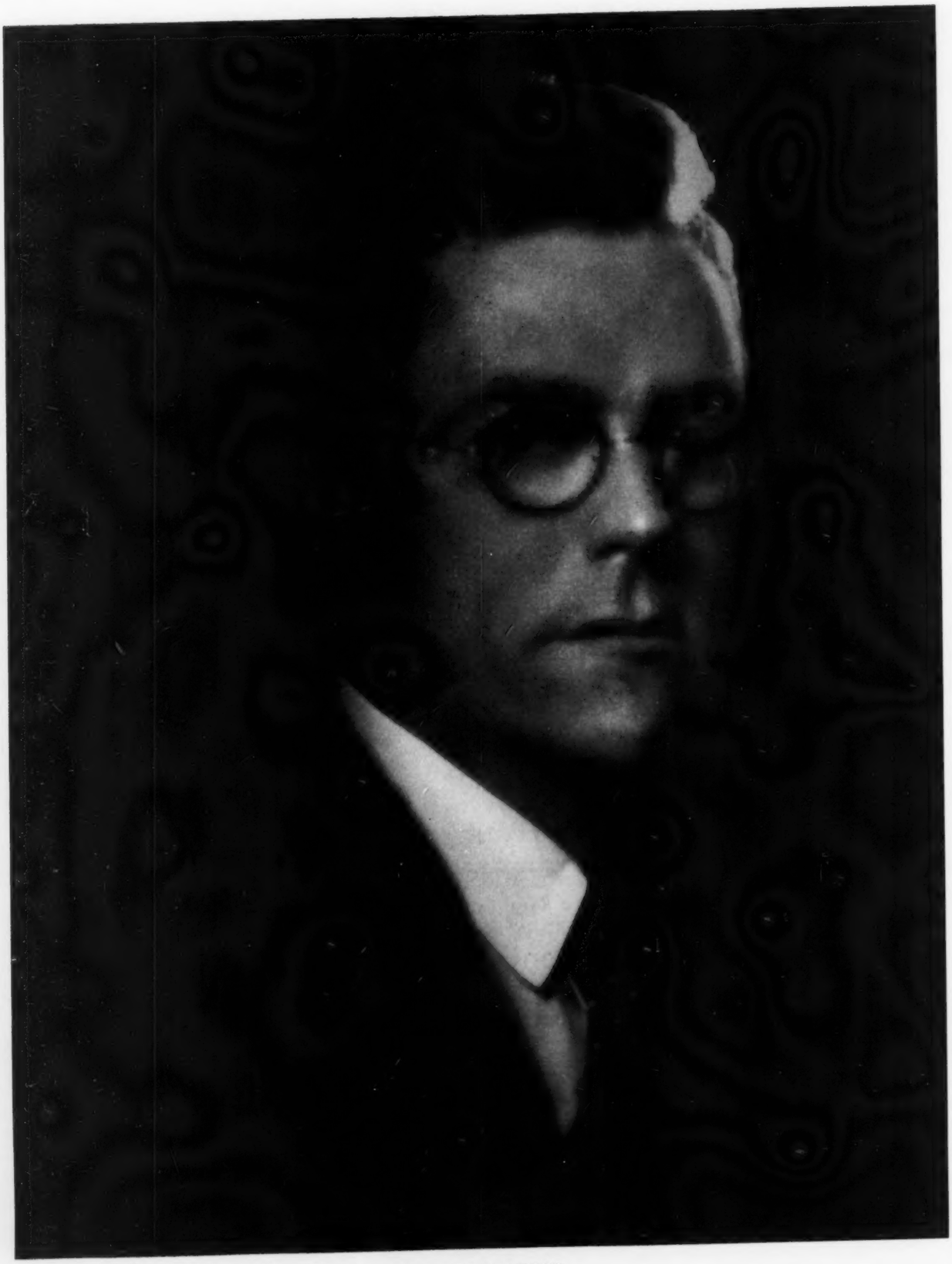

JOHN FREDRICK KELLY

In Memoriam

▲

It is with an overwhelming sense of loss that we announce the death, on November 16th, of John Fredrick Kelly, Managing Director of the Association of Iron and Steel Electrical Engineers and Editor of the Iron and Steel Engineer.

He was born in McKeesport, Pa., November 25th, 1880 and lived in the Pittsburgh district all his life. In his early years, before becoming associated with the Westinghouse Electric & Manufacturing Company, he was connected with various steel plants in this district. In 1909 he left the Westinghouse Company where he was employed in the office of manager of works, to go to the electrical department of the National Tube Company at McKeesport. In 1917 he was elected National Secretary of the Association of Iron and Steel Electrical Engineers. In 1918 he left the National Tube Company and established A. I. & S. E. E. offices in Pittsburgh. He was later made Managing Director of the Association and Editor of the Iron and Steel Engineer.

Mr. Kelly was one of the best known figures in the Iron and Steel Industry. He knew and studied the Industry from every angle. This knowledge and experience he used to build the A. I. & S. E. E. to its present prominent position among the National Engineering Societies. In his long career with the Association, and under his guidance, the Iron and Steel Engineer was founded as well as the Combustion, Lubrication, Mechanical and Welding Divisions. The original Electrical Division was founded in 1907. It was his dream and ambition that the Association should answer every engineering need in the Iron and Steel Industry. Toward the achievement of that result he labored unceasingly and tirelessly.

He is gone—our friend, counsellor and associate; true we have memories, fond and wonderful memories of him, but even they cannot quiet the ache in the hearts of all of us.

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Precision Rolling Mills

By S. M. WECKSTEIN.
Asst. Chief Engineer, Timken Roller Bearing Company, Canton, Ohio.

Paper presented at the A. I. & S. E. E. Annual Convention held in Cleveland, Ohio, September 18, 19 and 20, 1934.

The high speed production of strip and sheets held to close tolerances on gauge was made possible by the modern backed up mill. Anti-friction bearings have played a large part in this development. The ability of the bearings to operate at uniform temperatures, at the various speeds required in the continuous mill, made precision rolling possible. In addition, the large reduction in power costs of rolling and the reduction in bearing wear has made the anti-friction bearing a paying proposition in this highly developed precision mill.

S. M. WECKSTEIN

Recent developments in general industry and especially in the automotive industry have brought forth a demand for similar or even greater precision of the products generally rolled in merchant mills. Unfortunately this type of mill had not kept pace with the general development toward greater precision. The result was that a number of companies, who have been able to produce a product held closer than standard commercial tolerances, have enjoyed a greater volume of business and have created a general demand for closer tolerances. The fulfillment of these requirements can only be met by proper mill practice, suitable mill arrangement and the proper equipment.

Good merchant mill practice requires proper heating of the billets; control of scale; elimination of undue stretching and twisting of the material during rolling; control of temperature during rolling and efficient handling and cooling after product leaves the mill.

Mill arrangement depends entirely on the range of products, size of orders, diversity of orders and size of plant. The continuous mill and the semi-continuous mill are the two general types to be considered.

The continuous mill has the advantage of low first cost and low operating cost. It is well adapted for rolling large tonnages of narrow strip, skelp, flats, angles and merchant bars. Such mills are justified in large steel plants where the tonnage requirements for merchant bars is large and where the range of product is limited. Specialties and jobbing orders are usually handled on other mills in the plant.

The semi-continuous mill is more suitable for high-quality products and where specialties and jobbing orders of small tonnages must be rolled on one mill. These mills are usually arranged with several roughing stands for continuous rolling and with intermediate and finishing arranged to permit the product rolled to run free after each roll pass.

In order to obtain an accurate product on either of the above types of mills, proper equipment must be available. This is even more true of the full continuous mill when the rolling mill stands are considered from the standpoint of rolling accurate rounds. The delivery of an accurate round from the finishing stand is dependent upon the delivery of an exact section from the next preceding stand of the mill and this section is in turn dependent upon the delivery of an accurate section from the preceding stands in the mill. In other words the accuracy of the finished product is a function, not alone of the finishing pass, but of each preceding operation. In order to assure this considerable skill is required on the part of the operator in the adjustment of the sections in the various roll stands. Since the product of the section area and the delivery speed must be a constant for all the roll stands it can readily be seen that an adjustment in section in any stand must be accompanied by a corresponding adjustment in roll speed. A section adjustment in one stand may require adjustments in some of the other stands both in section and roll speed. This naturally means constant vigilance on the part of the operators and a possible large scrap loss during the period of the proper setting of the various roll sections or passes.

It is in the maintenance of this accuracy and also in the relief of the operator from the necessity of constant pass readjustment that tapered roller bearings play an important part. The roller bearing does not show any wear as compared with plain bearings.

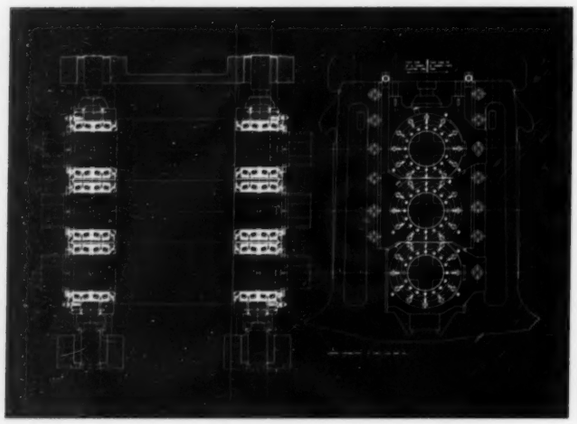

FIG. 1

By taking advantage of this feature it is possible to obtain perfect alignment and setting of the rolls and to maintain this setting indefinitely. It is also possible by proper design to make provision on the mill for adjusting devices which will permit setting the rolls or changing this setting by small increments in a minimum of time and without the cut and try method used on plain bearings. Once adjusted, the operator can be sure that the rolls will stay put and the only adjustments which he need consider are those required to compensate for wear in the roll passes. With this close control in the roughing stands as well as in the finishing stands a quality product is assured.

Since precision rolling is a matter of roll setting and pass alignment along with experience it will be interesting to study the methods of applying tapered roller bearings on the roll necks of merchant mills and especially the various provisions made for adjusting the roll passes. Figures 1 to 3 show the general arrangement and the details of mounting the bearings on a 3 high bar mill. The same size of bearing is used on all the roll necks and the application is the same except on the floating end of the middle roll. Each bearing is assembled in a bearing box forming a complete unit that can readily be slipped off and on the roll neck. The bottom roll and bearing boxes are fitted directly into the mill housing. The middle roll and bearing boxes are made so that the top roll bearing boxes can be fitted into them. In this way the middle box is located on the housing ledge by means of wedges under the housing cap. The bottom roll is carried on the bottom screw, while the top roll is balanced from the top lifting rods. The right hand view shows the fixed side of the mill while the left hand view shows the floating side of the mill.

Figures 2 and 3 show the detail construction. Figure 2 shows on the right-hand side the construction used for the fixed end of the top and bottom rolls. Each bearing is mounted as a unit in the bearing box, and the entire assembly, together with inside and outside filler rings, is slid on the neck and clamped by means of the nut shown. To reduce the cost of the rolls and eliminate threading them, a groove is cut in the neck and a two-piece threaded ring is fitted and doweled in the groove. The nut is bolted to the keyed filler ring after the bearing has been pulled up tight on the neck and against the inside filler ring. To obtain a very fine adjustment increment on the locking arrangement the following scheme is used. The keyed outer filler ring has a proper number of equally spaced tapped holes. The nut has an odd number (one more or one less) of holes drilled in it to receive the locking cap screw. The bearing box is provided with a special flange used for the alignment of the passes. With the bearing fixed to the neck, as described, the entire roll can be moved in or out the desired amount merely by adjusting the push-and-pull nuts in contact with the bearing-box flange.

The construction used on the floating end of the top and bottom roll is shown in the left-hand side of Figure 2. It will be noted that the bearing mounting is the same as the fixed end. The bearing box itself

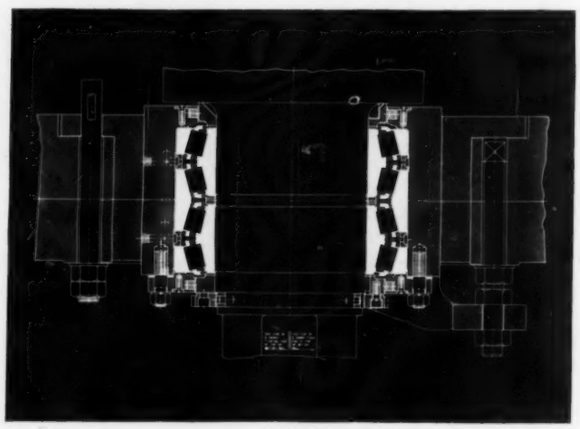

FIG. 2

is made without a flange and is not located endwise in the mill housing. In this way it can float in the mill housing and properly position itself when pass alignment is made or when roll expansion occurs.

The mounting of the bearings on the middle-roll necks is slightly different at each end of the roll, as shown in Figure 3. The two bearing chocks are made exactly the same and are rigidly clamped down on the ledge in the housing. They are also bolted to the housing through the flanges, as shown. Provision for expansion must therefore be made by the floating of the cones on one of the necks of the middle roll, as illustrated in the left-hand side of Figure 3. It is to be understood that the roll necks are exactly the same at both ends. The provisions for floating are obtained by a slight change in the design of the inner and outer filler rings. The right-hand half of the illustration shows the fixed end of the roll, which is the same as mounting used for the bearings of the top and bottom rolls.

The bearings shown in these illustrations are provided with cup and cone spacers. These spacers are ground to exact size so as to give the predetermined running clearance in the bearing and are supplied as part of the bearing. The inner and outer filler rings as well as the cone, or inner race, spacer ring are slotted to permit lubricant to reach the contacting surfaces and also to get down under the races, which are fitted with a given looseness on the roll necks. The grease for lubricating the bearings is

supplied from two distinct inlets which register with the annular groove and holes drilled in the cup, or outer race spacers. This assures a uniform supply of lubricant to all parts of the bearings. It also has been found necessary to vent all the bearing boxes to eliminate air pockets, which in many cases caused lack of lubrication, with consequent bearing failures. The closures for retaining the lubricant and excluding water and scale are of special design. The details of the closures will be discussed farther on.

In view of the fact that the bearings are mounted loosely on the necks, it has been necessary to establish the proper looseness for various size necks. It has been found that the clamping arrangement used very definitely retards the amount of neck wear due to the loose fit. It has further been definitely established that on two- and three-high merchant mills in sizes from 28-in. to 16-in. roll diameter, the rolls are worn out long before the neck wear becomes a factor in the operation of the mill.

On smaller mills operating at higher speeds, the more rapid roll-neck wear has dictated a design calling for races fitted tight on the necks, as shown in Figure 4. This layout features the use of a two-row bearing, but the same principle of mounting has worked out in service in a high-speed mill using four-row bearings. The mounting of the bearings on all the necks is the same. The inner races are fitted with a press fit of from 0.0005 to 0.002 in. tight and in addition are clamped up tight by the same locking arrangement as used on the slower speed mills. The design of the bearing box is altered so as to provide for the easy removal of the bearings. The boxes are made so that the inner closure plate is a separate piece. Also the inner filler ring is pro-

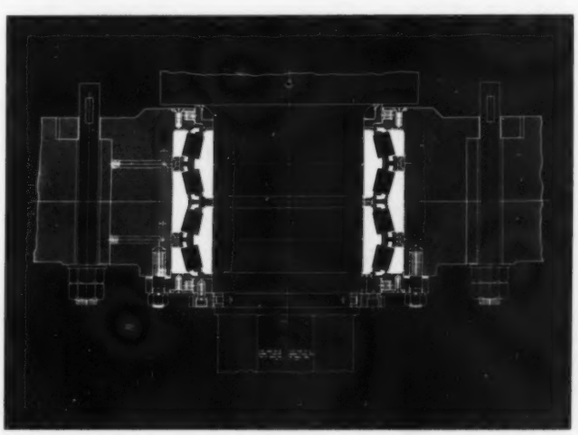

FIG. 3

vided with a shoulder. When the inner closure is bolted to the bearing box, a special split plate from 1/8 to 3/16 in. thick is inserted between them. The bearing box, with inner filler ring, inner closure, separating plate, bearings, outer filler ring, and outer closure, is assembled as a unit, heated in oil at about 300 deg. fahr., and easily slipped on the roll neck. The locking nut is then added, and the assembly is complete. To remove the bearings, the split plate is removed, and the inner closure is drawn up tight to the bearing box. The shoulder on the filler ring then contacts with the inner closure, to which pressure can be applied by means of a press or properly de-

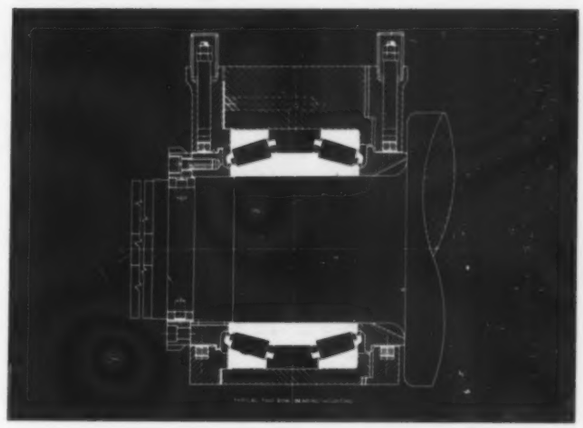

FIG. 4

signed puller. Very little difficulty is encountered in removing the bearings.

Bearing set up in this design is obtained by means of shims between the outer closure plate and bearing chock. The set up can be varied to suit the speed of the bearings and the accuracy desired.

In 1931 the writer presented a paper before the American Society of Mechanical Engineers on the subject of the Application of tapered roller bearings in Merchant Mills. Mr. A. G. Witting, Chief Engineer, Illinois Steel Co., Gary, Ind., presented a written discussion of the writer's paper. He covered carefully various points brought out by the writer. There is one point which was very important and I am therefore quoting him verbatim.

"There is another factor that may have to be considered because it may affect the rolling costs more than the expense for rolls and the bearings themselves; this is the ease with which a roll change can be made. In a mill where such changes occur frequently, perhaps several times a day, it is out of the question to have bearings that must be pressed off the rolls, whether it takes 80 or only 10 tons. It is also impractical and expensive to have a great number of spare sets all made up beforehand.

"To make the application of roller-type bearings practical for an ordinary mill, even provided that

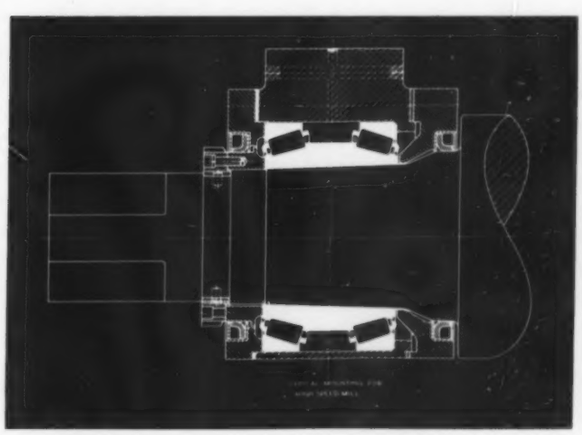

FIG. 5

the saving in power and longer life of the bearings compensate for the higher first cost, it is necessary that the bearing is assembled in one piece and that the roll neck and the inner race of the bearing are made tapered so that the bearing can be quickly slipped on the roll neck and located in its proper place by a whack of a sledge hammer, and similarly loosened, ready to be lifted off, by a hammer blow."

A design such as suggested by Mr. Witting has been worked out as shown in Figure 5. A two row bearing with a tapered bore is here fitted on a tapered neck. The general mounting of the bearing is the same as that shown in Figure 4 except that the inner filler ring is eliminated. Here again, instead of making the inner closure integral with the bearing box a separate piece has been used. It is quite possible that in the majority of cases, it will be possible to remove the bearing and box from the neck by a hammer blow. It was felt advisable however, to incorporate in this design the safety feature which is

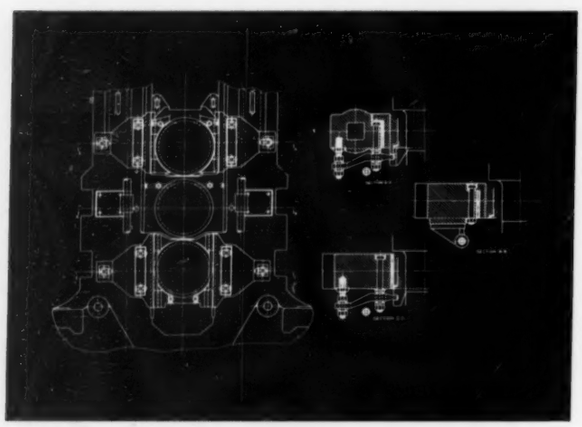

FIG. 6

shown. Should the bearing stick tight on the neck it will be possible to remove the split filler plate shown. This will permit the inner closure to come in contact with the inner race of the bearing and by applying pressure on the inner closure the bearing can be easily removed.

The preceding layouts have shown the various means of applying the bearings on the necks and have mentioned adjusting devices for the alignment of the passes. A study of some of these devices will be interesting especially since pass alignment is essential if accuracy is required.

Figure 6 shows a device similar to that used on the 28" 3-high bar mills at the plant of The Timken Steel & Tube Company. The top and bottom roll bearing boxes on one side of the mill are provided with lugs in which slots are machined. Special clamps fitting into the slots are bolted to the mill housing. By the use of ball seats and special washers, proper functioning of the clamps can be obtained from the push-and-pull nuts at the extreme ends. The holes in the clamps are elongated so that the clamps can be slid out of the way when a roll change is made. It is advisable to harden the faces of the slots in the lugs or to insert hardened steel liners to prevent pounding out in service. This construction is clearly shown in sections "AA" and "CC". Section "BB" shows how the middle roll bearing chocks are fixed in the mill housing.

Another device very successfully used on The Timken Steel & Tube Company merchant mills and on other similar mills in shown in Figure 2. Pass

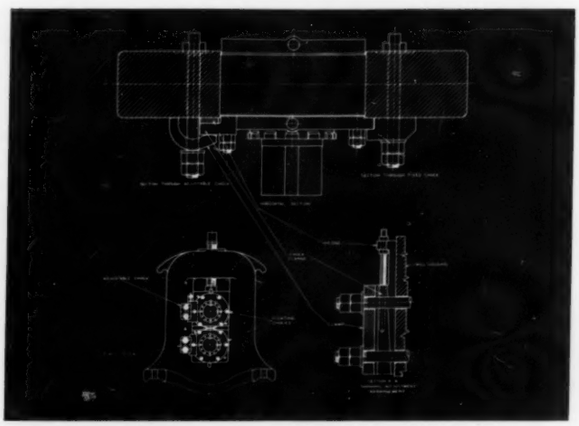

FIG. 7

adjustment is obtained by designing the chock at one side of the mill with an extending lug which is fixed to the mill housing by means of a push-and-pull bolt and nut arrangement. The chocks at the opposite end of the roll do not have the lug and are permitted to float in the mill housing. In this way the setting of the roll passes is obtained from one end of the mill.

Still another scheme successfully used is that shown in Figure 7. From the end view of the mill and the right hand side of the horizontal section through the housing it will be seen that the bearing chock on one end of the bottom roll is fixed to the mill housing by means of a suitable clamp. On the same side of the mill the top roll bearing box is fixed to the housing through an adjusting device. This arrangement consists of an adjustable wedge which is inserted between the mill housing and a special flange on the bearing chock. The flange is bolted to the mill housing by means of a special clamp. By loosening the nuts holding the clamp, the wedge can be adjusted in or out to give the desired roll setting. On both rolls the bearing chocks at the opposite end of the mill are permitted to float in the housing to take care of expansion and ease of pass alignment.

Considerable attention has recently been given to vertical mills. The twisting and guiding of small bars necessitates small guide clearances and any resistance in the path of a small bar traveling at high speed may result in considerable scrap loss. These twist guides can be eliminated by the use of vertical mills. The rolls in these mills should be adjustable up and down to properly line up the passes with the preceding horizontal mills. Provision should be made for accurate pass adjustment and for longitudinal movement of the rolls with respect to each other.

Roller bearings are required in this type of mill since they can be properly enclosed and protected against entrance of scale and water. The design shown in Figure 8 shows the general application on

an 11 in. vertical finishing mill which has been in service for about five years. The mounting of the bearings is practically the same as for the horizontal mills. The closures are more positive and flingers forming labyrinths are used. The rolls are hung from the top bearing and are easily removed. The

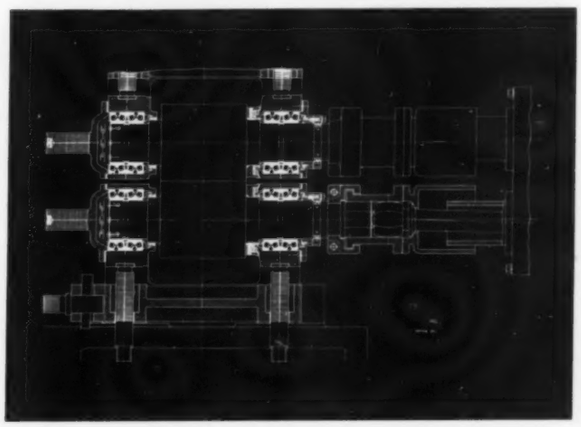

FIG. 8

bearings, because of their thrust carrying capacity, easily support the weights of the roll and boxes and the thrust loads from rolling. The bottom boxes are permitted to float so as to take care of roll expansion and not to interfere with pass alignment.

The top boxes are designed so as to properly take care of the pass alignment of the rolls. Figure 9 shows the top bearing closure to be designed with an extension having six threads per inch. A special bracket is bolted to the mill housing and attached to the threaded extension of the bearing box cap by means of two jam nuts and a specially designed adjusting plate. The bracket has 23 equally spaced holes and the adjusting plate 24 equally spaced holes. By loosening the jam nuts and by tightening or loosening the adjusting plate an increment of vertical rise and fall of the roll of 0.0003 inches can be obtained. When the desired set up is reached the adjusting plate is locked to the bracket by means of a pin inserted in the two mating holes. The jam nuts are brought up tight to hold the set up rigidly.

No attempt has been made in this paper to discuss the savings in power, lubrication and general maintenance which are derived from the use of tapered roller bearings in merchant mills. This subject has been covered in previous papers. There are also a number of mills so equipped which have been in operation for some time and on which records of maintenance costs have been kept. It would be interesting to have this data presented to the industry.

I have been asked to add a few comments on the use of anti-friction bearing thrust units in connection with rolls equipped with ordinary type plain bearings or with composition bearings. I have not prepared any slides showing the construction of the thrust unit since there is still some question about various details of the design. We believe that we are on the right track even though on some test jobs the results have not been entirely satisfactory.

We did quite a lot of experimental work in one plant. Thrust units were applied on the rolls of the last two stands of a high speed continuous mill. Several difficulties were encountered. First, it was found that it was hard to apply the thrust unit to the roll with the accuracy required. Due to the high speed a small amount of misalignment caused considerable run-out and a consequent pinching of the bearings in the thrust units. Second, it was found that the condition of the wobblers and pods had to be watched carefully. Worn wobblers and pods caused a thrust load considerably in excess of the capacity of the bearings used on the job. This second condition can undoubtedly be licked by the use of universal couplings.

The Illinois Steel Company of Gary, Ind., have built some thrust units with Timken bearings and have placed them in service. Maybe some of their men present can tell us just what their experience has been. I do not believe they have a sufficient number of units in service to give conclusive results.

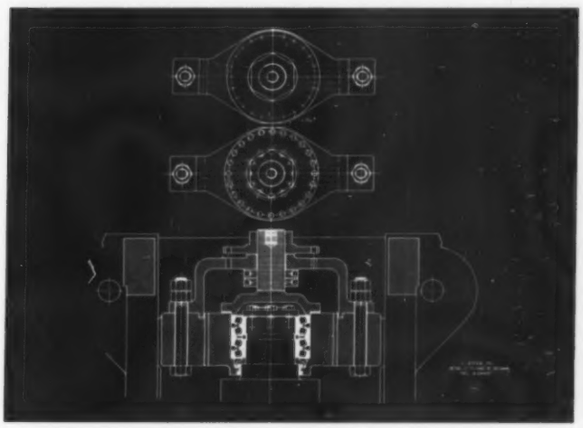

FIG. 9

We have been working with the engineering departments of a few other mills on the design of these thrust units. It is now up to the operating departments to install them and to work out the various operating difficulties encountered.

In closing there is another point I want to mention. This does not deal with precision rolling but should be of interest to all who are using or intend to use anti-friction bearings.

During the past few years we have been working in conjunction with our metallurgical department, with some of the rolling mills and with other interested companies on a means of prolonging bearing life. We have now worked out an oil tank into which bearings which have been in service for a long time can be placed and kept for a designated period of time at a constant temperature. We find that by drawing the hardness back, the bearings are rejuvenated and their life considerably increased. This tank can also be used on rolls, pinions and other parts which have been work hardened.

Discussion

Discussion presented by

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S. M. Weckstein, Asst. Chief Engineer, Timken Roller Bearing Company, Canton, Ohio.

J. A. Clauss, Chief Engineer, Great Lakes Steel Corp., Ecorse, Mich.

F. B. Crosby: Some twenty years ago the Morgan Construction Company firmly believing that it was possible, with a suitable precision roll stand, to produce hot-rolled rounds within far smaller tolerances than those prescribed for this class of work, designed and built three such mills. These were installed and placed in operation just before the heavy war-demand for all kinds of rolled steel products necessitated the subordination of all thought of precision work, to tonnage. This demand for tonnage held back the development of precision rolling on hot mills for nearly two decades.

Nevertheless, during the limited period in which we were permitted to study the operation of our pioneer precision mills, we learned a great deal from them, so that when, within the past year a new and insistent demand for a higher degree of perfection in hot-rolled rounds manifested itself, we were in a particularly good position to embody our earlier experience in a strictly up to date design of a precision roll housing.

Such a precision mill was purchased from us by an eastern steel company in the early part of this year, largely on their faith in our rolling mill experience in general, and on their own appraisal of the design which we submitted to them. This mill was installed and placed in commercial operation without appreciable difficulty of any sort, on July 18, 1934, (and with results fully justifying our most optimistic expectations).

Billets of silicon spring steel 3¼″x3¼″x4′ were roughed down in a 3-high hand mill and finished in a 6-stand Belgium train, in which our precision roll stand, comprising both horizontal and vertical rolls replaced the original 2-high finishing stand. The finished bar first rolled was nominally .700″ in diameter, for which size commercial tolerances for hot-rolled rounds are ± .008″ with a maximum permissible difference of .012″ between the maximum and minimum diameters at a given cross section.

Approximately ten tons of finished rounds were rolled the first day without a cobble and with a degree of precision highly satisfactory to our customer and to ourselves. Subsequent operations as the crew became accustomed to the mill have demonstrated that with reasonable attention to the many factors involved, such as quality of steel, uniformity of heating, correct sections out of the leader, etc , hot-rolled rounds of this size, which will not vary more than ± .002″, can be readily produced on such a mill, with many individual bars of even greater precision.

With experience and careful attention to detail commercial hot-rolled rounds well within accepted standard tolerances can be produced by usual methods and common practice. Due, however, to the limitations in human skill and inability always to control perfectly the many factors involved, some variations will inevitably be found in the finished rounds. This variation usually manifests itself at the parting of the finishing pass. If, therefore, the highest possible degree of precision is to be secured, a final sizing operation is necessary.

We secure the desired high degree of accuracy by intentionally making the nominal round in the last horizontal pass, a few thousandths full at the parting of the rolls and remove this fullness by means of a pair of independently driven vertical rolls, readily adjustable but rigidly mounted, in close proximity to, and in the same housing with, the horizontal rolls. It is of course impossible to hold by means of guides, such a nearly round section as issues from the horizontal pass, in such a manner as to insure the vertical rolls working on the desired section-axis, even with very tight guides. In any case very tight guides would be likely to scratch the bar It is evident therefore that the vertical rolls should be located as close as possible to the horizontal rolls in order that the section from the horizontal rolls shall not deflect or rotate and shall enter the vertical roll pass in such a manner as to remove the intentional fullness and deliver a round of the desired precision.

This precision roll stand is a combination housing in which are mounted both the horizontal and vertical rolls. The housing and all parts under strain are of cast steel. That portion of the housing carrying the horizontal rolls follows our standard closed top construction with horizontal wedge adjusting screws for the bottom rolls and the usual vertical screws, with supporting means, for the top roll adjustment. Special attention is called to our device for holding down the bottom roll and which at the same time takes up any slack in the driving spindles. This detail is important since any sudden acceleration or retardation of the bottom roll with respect to the top roll, due to lost motion in the drive spindle couplings, will produce a deflection of the front end of the bar which may render more difficult, or even impossible, the proper entry of the bar into the vertical pass. The horizontal rolls may be equipped either with Micarta neck bearings or with our Morgoil bearing.

The vertical rolls are mounted in a self-contained unit or tray located in a separate window of the roll housing. When changing these rolls a complete spare tray in which the new rolls have been properly adjusted, and, with the guides assembled in place, may be quickly and easily substituted for the unit removed from service. This construction materially facilitates rapid roll changes.

The vertical rolls are independently driven by a vertical motor of suitable electrical and mechanical characteristics. In general, this motor is a standard vertical design totally enclosed, fan ventilated, and equipped with a special shaft extension of exact dimensions specified by us, but furnished without its usual lower bearing bracket, supporting ring or feet, and bearing, all of which details are an integral part of our design.

The power required for removing the intentional

fullness left by the horizontal pass is obviously relatively small.

The vertical rolls are mounted in Micarta bearings and flood lubricated with water. Each vertical roll, is accurately adjustable, horizontally and vertically, independently of the other. The vertical adjustment is secured by means of wedges below, and an adjusting screw or clamp above. Both vertical rolls may be moved as a unit in order to align the respective passes of the vertical and horizontal rolls. The driving unit including the vertical motor is also adjustably mounted to cover the face of the horizontal rolls.

As stated above it is essential that the vertical rolls be as close as possible to the horizontal rolls. This of course limits the available space for delivery guides from the horizontal rolls and entry guides for the vertical rolls. It also increases the difficulty of clearing possible cobbles between the two sets of rolls and renders it difficult, if not impossible, for the roller to inspect the section leaving the horizontal pass. These and other considerations have led us to a type of construction in which the vertical rolls are carried in a cage housing which in turn is attached to the horizontal roll housing by means of rugged roller-bearing hinges, in such a manner that the entire cage housing, vertical rolls and driving unit, may be swung out away from the horizontal rolls. When in the closed position the cage housing is rigidly clamped to the main housing by means of swinging links and wedges. The rolling stresses set up within the vertical roll system are self-contained within the tray and furthermore as it is desirable always to operate with a little tension on the stock, the normal reaction tends to hold the cage housing firmly in its closed position.

This construction greatly facilitates—

1—Adjustment of guides on both horizontal and vertical rolls.

2—Removal of cobbles from between the horizontal and vertical rolls.

3—Inspection of section leaving the horizontal rolls and adjustment for finished section, since with the cage housing open a short trial bar can be passed through the horizontal rolls and readily inspected without passing through the vertical rolls. This is impossible without the swinging cage-housing construction.

4—Adjustment of vertical rolls or substitution of new tray can be made while trial bars or commercial rounds are being put through the horizontal rolls.

5—For ordinary commercial rounds, the cage housing may remain closed but with the vertical roll tray removed, which leaves ample clearance for the ordinary non-precision rounds to pass through the cage housing.

We call special attention to the adjusting clamps for the horizontal rolls. Hardened steel inserts in the bearing chocks insure accurate application of clamping pressure and largely eliminate danger of cramping the bearings. The retaining bolts pass through the housing and are held firmly with a short section in tension. The clamps are easily adjustable and maintained in a fixed position in space, consequently the bearing chocks are definitely located at all times with respect to the end of the roll barrel and without appreciable pressure between the roll barrel and renewable thrust collars. This detail is important in that it materially reduces wear if the Micarta thrust collars are used. If Morgoil bearings for the horizontal rolls are used, we, of course, supply our standard clamping details for this type of bearing.

In conclusion it is but fair to state that while we can furnish, in this precision roll stand, a "tool" accurately and ruggedly constructed, and which, with reasonable skill and attention to detail, will produce results long desired, nevertheless, this precision roll stand will not make a perfect round out of a poor one, but **it will** make a **good** round **better.**

As with any other product which is the result of many carefully coordinated processes every effort must be concentrated on the earlier stages if a quality product is expected. In this case the oval delivered from the leader must be as nearly perfect as possible.

We make no guarantee as to the degree of accuracy which will be secured with our precision roll stand. We can supply an excellent tool but credit for ultimate precision obtained must of necessity go largely to the roller, for his attention to detail throughout the entire procedure of heating and rolling. Experience to date, however, seems to indicate that this type of precision roll stand may be expected to produce a hot rolled product which will largely eliminate the necessity for subsequent pickling and cold rolling and that its first cost should, therefore, be easily justified.

F. H. Moyer: We have made a very complete study of the rolling of close tolerance rounds; particularly in the use of an auxiliary mill, following the last horizontal stand in a bar mill and have come to the conclusion that the proper place in which to produce these rounds is in the bar mill itself without any added equipment to remedy defective rolling after the material has been delivered from the finishing pass.

With the above in mind, we have developed a thrust bearing to be applied to both top and bottom rolls, of say the last two horizontal stands of the mill, these thrust bearings being so constructed that both top and bottom rolls will be held accurately in pass alignment longitudinally during the entire rolling operation.

These bearings are provided with a very accurate micrometer end adjustment which, after the rolls are set in correct rolling position, the bearing setting is locked and remains in this position, eliminating all end shifting of rolls as a factor in diametral measurement of the bars, except predetermined clearance in thrust bearing itself.

We have a set of these bearings (on the finishing stand only) in operation in one of the plants of the Youngstown Sheet & Tube Co., and while we have no official information to give out at the present time, the tolerances obtained on the first few rollings averages from "plus .005" to "plus .007" on bars ranging from 13/16" to 15/16" nominal diameter.

We expect to have exact data later.

We feel that with this method of positively holding the rolls against longitudinal movement, we have eliminated what has formerly been an uncontrolled factor in the rolling of rounds; the other factors, i.e., shape of the pass in the rolls, and wear of the roll pass being in the hands of the mill operators.

C. W. Meyers: I am willing to go along with

what Mr. Moyer said relative to rolling of close tolerance rounds. While we have up to this time done nothing along this line we have however made a very careful study of it and I have about reached conclusion that before we consider the installation of an extra stand of vertical rolls we shall check up on our bearing problems. The composition bearings have improved rolling of rounds a lot but the collars of this and other types of bearings give us no end of trouble in trying to keep within close tolerance caused entirely by the end thrust which exists on practically all mills. The bearing that Mr. Moyer spoke about no doubt will overcome this trouble materially.

H. G. R. Bennett: I would like to ask Mr. Weckstein one question. In his talk he mentioned the fact that at the roughing end of the mill at Timken they use roller bearings, and when he spoke of the auxiliary precision stand which they have on one of their mills he also said they are equipped with roller bearings, but he did not say anything about the intermediate stands. I wonder if he will tell us something about those.

S. M. Weckstein: You gentlemen probably know that the formation of the Timken Steel & Tube Company was the result of the constant effort of the Timken Roller Bearing Company to develop proper steels for bearings. To do this effectively and economically it was necessary for us to increase our steel producing capacity and also to develop precision rolling methods.

In 1928 when we expanded our steel making facilities we installed a semi-continuous merchant mill. Since we already had a Belgian type mill which our operating men did not see fit to scrap, we used the available equipment together with the new equipment. We purchased nine stands of continuous mill equipped with Timken bearings, retained the plain bearing stands of the Belgian mill and added an eleven inch vertical and a horizontal stand equipped with Timken bearings.

At that time we also developed designs for changing over the plain bearing stands to Timken bearings. In view of the operating speeds and the job lot requirements of this mill we decided that our 1928 bearing mounting design would not give us the economical and precision results required. We have since developed a design, as illustrated in the paper, which would answer all requirements. However, due to the success obtained to date on the plain bearings and due to lack of appropriations for development work, we have been unable to make the change. We hope in the future to be able to test out some thrust units on these stands and also to eventually change them all over to the use of our bearings mounted directly on the necks.

J. A. Clauss: The production of precision rounds due to the introduction of knee action springs to the automobile, becomes the vital concern of the steel mill operator. We have had this problem thrust on us more intensely the past two years than ever before.

There is such a difference of opinion as to what constitutes a precision round that it seems advisable to list the standard tolerances in common use for various sizes of rounds.

MERCHANT MILLS
PERMISSIBLE VARIATIONS FOR ROUNDS AND SQUARES

Size		Tolerances		Out of	Special Tolerances		
Over	Up to & Inc.	Over	& Under	Round	Over	Under	Out of Round
.....	5/16"	.007	.007	.010	.005	.005	.008
5/16"	5/8" inc.	.007	.007	.010	.005	.005	.008
5/8"	7/8"	.008	.008	.012	.006	.006	.009
7/8"	1"	.009	.009	.013	.007	.007	.010
1"	1 1/8"	.010	.010	.015	.008	.008	.012
1 1/8"	1 1/4"	.011	.011	.016	.009	.009	.013
1 1/4"	1 3/8"	.012	.012	.018	.010	.010	.015
1 3/8"	1 1/2"	.015	.015	.021	.012	.012	.018
1 1/2"	2"	.020	.015	.023	.015	.015	.022
2"	2 1/2"	.040	.....	.030	.030	.....	.023
2 1/2"	3 1/2"	.050	.....	.050	.....	.....	.....
3 1/2"	4 1/2"	.060	.....	.060	.....	.....	.....
Over 4 1/2"		.075	.....	.075	.....	.....	.....

By special tolerances is meant bars that are rolled for special orders, such as bars for rolled threads, rivets, etc. These orders require each bar to be sized and carry an extra for cold inspection and sizing.

Heretofore, when a tolerance closer than standard was required, the bars were generally cold rolled or cold drawn for which an extra charge was made.

Today, when we talk about precision rounds, we have in mind a hot rolled round 3/4" dia. with an out-of-round tolerance of one and one-half thousandths plus or minus.

To ask the merchant mills to produce a round hot rolled bar of such close tolerance is asking the impossible, because our present knowledge of materials for roll making knows of no material for rolls which will hold the roll pass to this close tolerance for any length of time. The variations of temperature, material and wear of the roll pass are so rapid that, even though we may be able to deliver a bar of such close tolerance, it can not be accomplished for any great length of time, and, before adjustments can be made to compensate for the variables, a number of bars will have been produced and the question is—What are you going to do with this material and who is going to pay for the extra cost of sorting it out?

Then too, it takes time to make adjustments and frequent adjustments means loss of production. In an effort to overcome these difficulties we have seen the introduction of vertical rolls after the last finishing stand. The product from the pass in the vertical rolls is subject to the same variables as the product from the pass in the horizontal rolls.

Give the mill operator a well constructed and stiff roll stand, correctly turned grooves, and means for making easy adjustment and he can produce a good round without any vertical rolls.

On merchant mills recently constructed, rounds with tolerances much less than the standard tolerances are being produced; in fact, we have taken at random some 23/32 rounds of spring steel grade and put them through a so-called sizing mill and they were more out of round than before putting them through.

I am sure that none of the men present here today who are operators of the merchant mills wants to see a standard set for the industry of such close tolerances as is inferred by the term "Precision

Round". Precision rounds are properly the product of cold drawing or cold rolling and should be kept there. The merchant mill with its multiplicity of sections and rolls should not be saddled with this additional requirement.

C. W. Meyers: Along the line of rolling I do not believe that we have given it the special consideration it requires. When steel is produced it is given a lot of special attention by metallurgists and a lot of experimenting is done to improve quality, and a lot of progress has been made.

I doubt whether this can be applied to rolling. It is really believed that closer tolerance rounds can be rolled by proper heating, redesigning of passes, more balanced drafts, proper guide equipment and elimination of end thrust. After these items have been taken care of we can consider the necessity of vertical stand.

There is a lot of expense to be considered in the rolling of close tolerance rounds and increased costs will develop.

Steel Led In Safety Work*

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Thirty years ago, when a concerted program for accident prevention was unknown, the toll of industry in life and suffering was heavy. Included among the hazardous industries was steel, and to steel must be given most of the credit for the change that has taken place since then, for it was in the steel mills that the idea of "Safety First" originally found expression, later to be changed to "Safety First, Last and All the Time." It was the enthusiasm of the steel managements that proselyted for the new cult of safety until it spread over the entire industrial world.

When and by whom was the industrial safety movement started? There is no definite evidence, but the credit seems to belong to the late Thomas Lynch, one-time president of the Frick Coke Company, who, as far back as the late eighties, pronounced and insisted on the doctrine that "The Safety of Our Men Must Be Our First Consideration."

It was in 1906 that the management of the United States Steel Corporation, taking cognizance of the sporadic and unorganized work of some of its plant managers directed toward the prevention of accidents, determined to organize and extend the work, and organized a Committee of Safety to that end.

The late Elbert H. Gary, then Chairman of the Corporation, pledged on behalf of the directors that no funds needed to make the mills as safe as possible would ever be stinted.

A year or two later, in 1908, to be exact, the Association of Iron and Steel Electrical Engineers created a safety committee out of which grew the Cooperative Safety Congress held in Milwaukee in 1912, and from which, in turn, sprang the National Safety Council. This organization, supported by a large number of industries, devotes its energies to promulgating the cause of safety, and acts as a clearing house for information and ideas that promise to advance the cause.

This intensive effort was inaugurated with purely humanitarian motives, though it subsequently has been demonstrated that it also paid in dollars and cents, with substantial benefit both to employee and employer. So great have proved its advantages from a purely economic standpoint that one marvels how industrialists could have failed to recognize its necessity long before they did.

Obviously every accident, no matter how unimportant, involves some direct cost to the employer, and this is especially true in disabling injuries or death, entailing wage loss, medical attention, compensation payments, etc. But these direct costs do not tell the whole story of economic loss. To these we must add the indirect costs, estimated at about four times the direct. One then arrives at an accident bill that, if injuries had continued at the 1905 rate, would have been appalling, and would have meant enormous losses to employees and employers which would have been reflected in increased prices to consumers.

Some of these indirect costs are as follows:

1. Cost of time lost by the injured.
2. Cost of time lost by other employees who stop work when the accident occurs.
3. Cost of time lost by foreman, supervisors, etc.
4. Cost of first aid not compensated by insurance.
5. Cost of injury to tools.
6. Cost of interference with output.

It has been estimated that the saving in the steel industry alone in the twenty-eight years since the movement was inaugurated runs into billion-dollar figures. This saving has been reflected in the cost of steel to the consuming public.

* Reprinted from "Steel Facts" published by American Iron and Steel Institute.

Special Electrical Drives For Steel Cleaning and Processing Machines

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Paper presented at the A. I. & S. E. E. Annual Convention held in Cleveland, Ohio, September 18, 19 and 20, 1934.

For over thirty years the electrical engineers in the steel mills, in cooperation with the engineers of the electrical manufacturing companies, have successfully worked out the many problems involved in the main roll drive and the directly associated auxiliaries. With the major problems successfully solved, attention has been increasingly directed to the problems connected with the secondary processes in the manufacture of steel products. Particularly interesting examples are the individual drive of runout tables, the sectionalized control of roller tables through frequency motor-generator sets, and the reversing motors used in connection with the feeder and catcher tables. Several papers have been presented before the Association describing in detail the electrical features of such drives.

A. M. MacCUTCHEON

It is a privilege and a duty for the manufacturers of electric motors and controls to match the ingenuity of the steel mill engineer by furnishing the proper type of electrical apparatus to successfully drive the ingenious machines and supply power for the special drives which the steel mill engineer has conceived. Steel products play such a large part in the industrial life of today that the number of electrical drives in connection with the manufacture of steel and steel products is almost legion. This paper is devoted to machines and drives particularly relating to steel cleaning and processing. Only a small part of this field is covered in the selection of a few drives with which the authors are particularly familiar and with some of which drives the general membership of the Association may not be acquainted. Each installation could well be the subject of a complete paper. The drives are selected with the particular purpose of illustrating how the proper selection of motors, with suitable characteristics, best serves the requirements of a particular drive. Each drive is analyzed particularly from the viewpoint of the motor manufacturer, and while the control is referred to, no attempt is made to completely cover the control problems.

In selecting suitable motors for an unusual type of drive, the following should be carefully considered.

1. The work to be accomplished.
2. Space requirements.
3. The most suitable speed.
4. Method of Mounting.
5. Type of enclosure.
6. Operator's Convenience.
7. Electrical Characteristics.
8. Torque demand.
9. Dissipation of heat.
10. Protection against electrical and mechanical failure.

While the electrical performance, with relation to efficiency and power factor, should not be overlooked, usually on a secondary drive the advantages to be gained through continuous operation without delay far overbalances any slight necessary decrease in efficiency and power factor. The same is true of the cost. Compared with the cost of electrical equipment for the main mill, the cost of the electrical equipment for the secondary drive is relatively so small that improved results in production and continuity of service justify any reasonable increase in cost.

The following drives will be described in some detail from the standpoint of the problems encountered, the motors supplied, the control used, and the results secured.

STEEL CLEANING

Continuous Pickling of Sheet Steel

To handle the pickling of sheets delivered from a continuous mill, a continuous pickling process is most

desirable. In this installation steel strip is fed from coils first passing through the decoiler and leveler, and then passes to a shear for squaring and removing the fish tail. The sheet then enters a stitcher which stitches the forward end of the incoming sheet to the aft end of the sheet ahead. Beyond the stitcher is the No. 1 pinch roll controlling the sheet as it leaves the stitcher. Some time is required for the stitching operation and a surplus of material is accumulated beyond the stitcher pinch roll to permit the continuous passage of the sheet through the pickling vat irrespective of the time necessary for shearing and stitching. No. 2 pinch roll continuously feeds the sheet into the pickling vat. No. 3 pinch roll, beyond the vat, draws the continuous sheet from the tank and delivers it to the shear which cuts out the stitch.

The drive provides for the passage of the continuous sheet through the pickling bath at 40 to 160 feet per minute under the control of the operator. With the exception of those driving the shears and stitcher, motors used are d-c. 4 to 1 adjustable speed.

Close synchronization is required between the No. 2 pinch roll delivering the sheet to the pickling tank and No. 3 pinch roll which withdraws the sheet. This synchronization is cleverly accomplished through a rider roll of special material within the pickling chamber. If the No. 3 pinch roll beyond the bath is withdrawing material more rapidly than it is delivered field resistance is automatically reduced in the field of the No. 3 pinch roll motor. This is accomplished through the mechanical upward movement of the rider roll and vice versa. While it is evident that over a day's operation all of the units of the group handle the same amount of material, continuous synchronization of the sections of the drive other than the No. 2 and No. 3 pinch rolls is not necessary, the excess material between the shear pinch roll and the No. 2 pinch roll permitting of the necessary delay for stitching. After the material leaves the bath through the No. 3 pinch roll, it passes through a double shear for cutting out the stitch and then goes to a recoiler. Surplus material may be accumulated between the No. 3 pinch roll and the double shear.

Since rotary shears are not used, the shearing operation must be accomplished as quickly as possible and for this reason two motors in mechanical parallel are used, thus reducing the armature WR^2. With the development of low inertia high starting torque a-c. motors such as are used on feeder and catcher tables, it is probable that this type will be considered on future installations for the operation of the shear.

For a new drive where direct current is not available, it would be interesting to consider the use of a variable voltage motor-generator set for the primary control of all motors, secondary speed adjustments being secured through field control.

All control from the No. 1 pinch roll on is centralized at an operator's panel. Here are located tachometers for indicating the speed of each unit and rheostats for the primary speed control of the drive. Signal lights mounted on the panel indicate the position of the rider roll within the pickling tank. If automatic compensation is insufficient, correction may be made by the operator.

Motor List

Decoiler and Leveler
1—35 hp., 300-1200 r.p.m.
Shear
2—35 hp. Mill Type.
Stitcher
2—35 hp. Mill Type.
No. 1 Pinch Roll
1—20 hp., 400-1600 r.p.m.
No. 2 Pinch Roll
1—20 hp., 400-1600 r.p.m.
No. 3 Pinch Roll
1—35 hp., 300-1200 r.p.m.
Double Cut Shear
2—35 hp. Mill Type.
Recoiler
25 hp., 400-1600 r.p.m.
Upending Device for Delivering Coil to Conveyor
10 hp. Mill Type.

THE BILLETEER

The Association is fortunate in having this machine completely described in a paper presented at this session by Mr. George Lentz, inventor and designer. Any description of the functions and performance of the machine is, therefore, unnecessary.

No machine in recent years has presented more interesting problems in motor application nor has called for more diversity in motor characteristics. Motor drives are designed and applied to give extremely flexible operation in order that maximum production may be realized. Each function of the machine is accomplished with a motor designed to best perform that particular action.

The carriage is driven preferably by a two-speed motor specially designed for quick and frequent starting and stopping, as the tool must be quickly and accurately spotted over the flaw to be removed. The high speed is used for movement of the carriage in the return direction and the low speed is used for movement in the forward, or cutting, direction. It was originally believed that a maximum of 25 to 30 starts per minute would be the requirement, but the speed with which the flaw is removed and the skill which the operator attains has boosted this figure to over 50 times per minute. The motor is of the built-in type, with special ring mounting on the end of the machine.

The tool head is raised and lowered by means of a vertical gearmotor drive built into the top of the carriage, the motor being a torque motor, turning but a few revolutions at each operation, which may be as many as 25 times per minute. The transverse movement of the cutter head is accomplished manually by the operator.

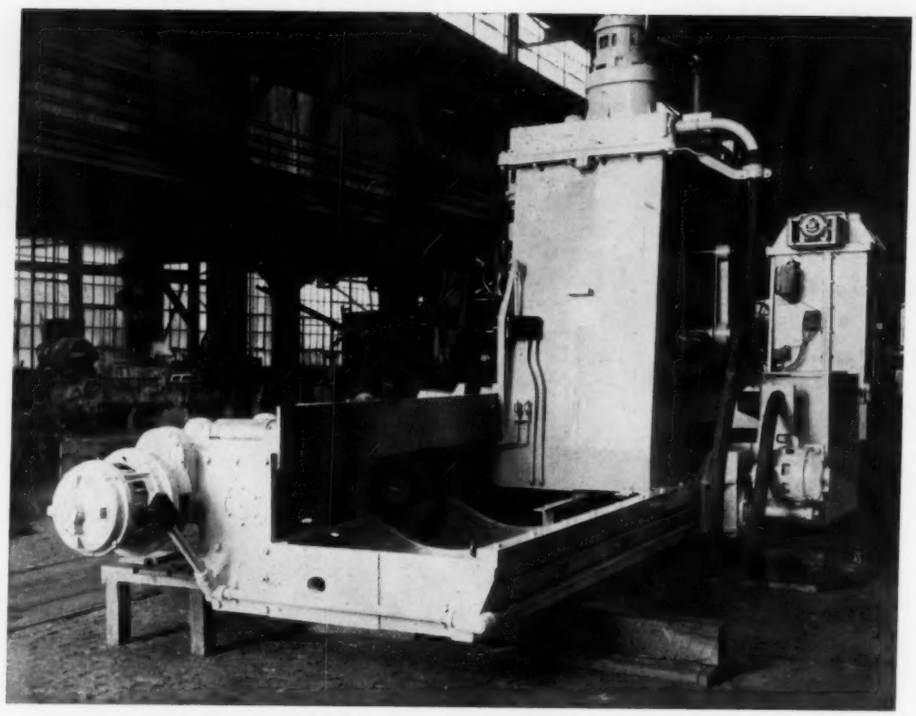
The tool head is driven by the only standard motor on the machine. The head turns continuously while the machine is in operation. The load is actually a series of peaks as the cutter teeth engage the metal. High maximum torque is necessary to pull through the heavy cuts taken where the flaws are deep.

The manipulator motor is a high torque motor which operates intermittently. It is mounted on the front end of the carriage, in a vertical position.

The chucking motor requires two torque charac-

teristics. For chucking it is either stalled with the windings connected in such a way as to give a reduced torque which the motor will be capable of delivering while stalled, or else it is stalled with primary resistance in the circuit to accomplish the same result. The chuck is released under a greater torque to ensure its breaking loose. The motor drives through an irreversible worm and power is removed from the motor terminals one second after the motor stalls by means of an automatic timing relay.

The sixth motor on the machine operates the table drive for charging and discharging the billets. This again is a special intermittent-duty, high torque motor and, like the carriage drive, is built on to the end of the machine.



The Billeteer—viewed from discharge end.

The control for this machine is particularly interesting in its interlocking features and in the master switches. Since this falls within the scope of Mr. Lentz' paper it will not be covered further in this paper.

The carriage drive, with its two-speed winding and its abnormally frequent starting, is such an interesting application that it will be considered in greater detail than the other drives.

The first machine was installed about four years ago. Since it was more or less of an experimental machine the motors used for driving were not designed for the application but, rather, were what the plant had available. An elevator type motor was first used for the carriage drive and was not successful. This was replaced by a slip ring type, crane motor, operated with secondary resistance in the circuit at all times. This motor operated the machine, but was very sluggish in action.

When the second machine was built the motors were designed for the machine. The carriage drive was a two-speed, 900 and 1800 r.p.m. motor with a special low-inertia rotor. The operation was exceedingly rapid and with the improvements that had been made in the machine and in the drive it was found that the carriage was being started at the rate of as high as 50 times per minute, whereas the motor had been designed for about 25. Of course, the motor would not stand this increased rate. To satisfactorily overcome the difficulties with as little trouble as possible, the motor was re-wound for a single speed, 900 r.p.m., and was equipped with a blower mounted integrally with the motor. This has made the drive successful with no change in the gearing necessary, and with a sacrifice in speed only on the return stroke, which is a relatively small part of the cycle. The blower was a decided help in keeping the motor cool because the ventilation of the motor provided by its own fan was very poor due to the fact that the motor ran at its full speed such a small percentage of the time. Most of the time it was standing still or starting and stopping.

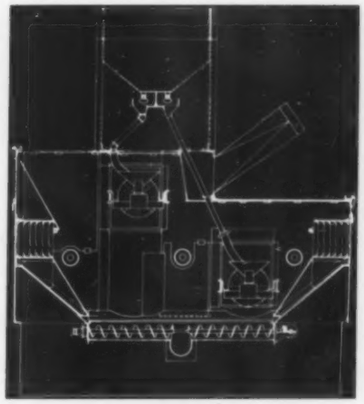
Later machines have been supplied with slower speed motors. With 60 cycle a-c. current the speeds are 1200 and 600. Where a large part of the work is accelerating and decelerating the motor, slower speeds are of primary importance in keeping the loss in the motor at a minimum.

THE AIRLESS WHEELABRATOR

Manufacturers: American Foundry Equipment Co., Mishawaka, Ind.

Steel shot or steel pellets have been found to be much superior to sand in cleaning processes; opening another field for the use of steel products. A great disadvantage of air blast cleaning equipment has been the high power cost of the compressed air. The manufacturers of the airless wheelabrator claim that a wheelabrator driven by a 15 hp. motor will clean more surface per hour than air blast equipment consuming 150 hp. and that the machine effectively replaces acid pickling, wire brushing, abrasive scrubbing and other methods of cleaning sheets, shapes, billets, slabs and forgings.

This method employs centrifugal, tangential and air dynamic forces rather than compressed air. Abrasive suitable for the work is fed by gravity from a storage hopper into the wheelabrator near the center of rotation. The wheel is driven at high speed by the motor referred to and the abrasive is ejected



To the left is illustrated the cabinet type wheelabrator: to the right is a longitudinal section of the wheelabrator cabinet; and above is a fully enclosed D-C gearmotor.

at the periphery of the wheel. The abrasive is thrown in a stream approximately 4 inches wide by by varying the angle of the nozzle the length of the effective blast stream may be varied from 10 to approximately 40".

The illustration is of a special cabinet machine unusually complete in its provisions for handling the billets to be cleaned, handling of the abrasive, and prevention of the escape of dust or abrasive from the cabinet.

An exhaust system provides for the separation of the abrasive from the scale and other removed material, and a conveyor and elevator system automatically returns the abrasive to the elevated hopper.

The billets are handled by two conveyor tables, one on either side of the cabinet. Each table extends from the center of the cabinet to a distance beyond equal to the maximum length of the work to be handled. Specially constructed vestibules at either end of the cabinet prevent the escape of dust or abrasive. The cabinet is equipped with two wheelabrators, one above and one below the work, so that the piece may be cleaned at the top and bottom simultaneously. Each table is driven by a 3 to 1 adjustable-speed d-c. gearmotor, providing 20-80 r.p.m. at the output shaft. This motor is of the planer type capable of reversing the table every 20 seconds under high speed operation. An adjustable speed motor is selected not only to provide for variable speed of the work under the wheel, but also to permit of a very rapid return of the piece prior to a second passage under the nozzles. The use of the 15 to 1 gearmotor avoided the supplying of a separate reducer. Because of the frequent reversals, an oversized gear unit with a steel housing was supplied.

Beyond the conveyor tables are two end tables for receiving and disposing of the billets. At the entry end of the conveyor table is a manipulator for turning and handling the billets. At the opposite end of the conveyor system is an ejector, or kickoff. The two end tables, manipulator and the ejector are driven by d-c. mill motors but in future installations low inertia high starting torque a-c motors will be considered.

Remote control of all motors is centered in a control panel conveniently located near the cabinet.

Motor List

Wheelabrators	2—15	hp., 1800 r.p.m. A-C.
Abrasive Elevator	1— 1½	hp., 1800 r.p.m. A-C.
Exhaust Motor	1—10	hp., 1800 r.p.m. A-C.
Agitator Motor	1— ¾	hp., 900 r.p.m. A-C.
Screw Conveyor	1—1½	hp. gearmotor 97 r.p.m. A-C.

The above motors cover all operations within the cabinet. Following is a list of the motors used in connection with the handling of the piece.

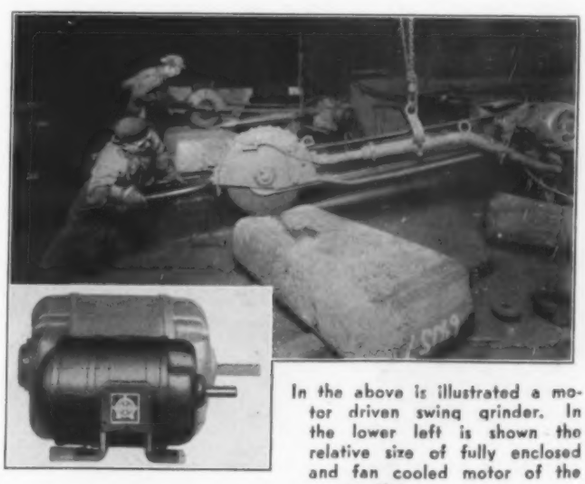
Conveyor Tables 2—7½ hp. 300-1200 r.p.m. D-C.
End Tables 2—5 hp. 750 r.p.m. D-C. mill motors
Kickoff 1—7½ hp. 750 r.p.m. D-C. mill motor
Manipulator 1—7½ hp. 750 r.p.m. D-C. mill motor

It is hoped that this most interesting installation may be more fully described in a later paper presented before the Association by one of the steel mill engineers associated in its operation; and that this paper will in detail outline the results secured as well as the special features of the control.

SWING GRINDERS

Swing grinders are used in many plants and are referred to in this paper as an illustration of direct application of the motor to the machine.

Ball-bearing motors are to be preferred since the motor moves through an arc and fully-enclosed mo-



In the above is illustrated a motor driven swing grinder. In the lower left is shown the relative size of fully enclosed and fan cooled motor of the same rating.

tors should be used unless the exhaust system is particularly effective. Because of the much smaller space and lighter weight, fan-cooled motors are more desirable than straight fully-enclosed.

Experience has demonstrated that swing grinder motors are subject to heavy overloads in the hands of a willing and enthusiastic operator and should be picked on a continuous rather than a short time basis of rating, even though the operation is somewhat intermittent. Even then the rating picked should be liberal compared with the probable demand.

STEEL PROCESSING

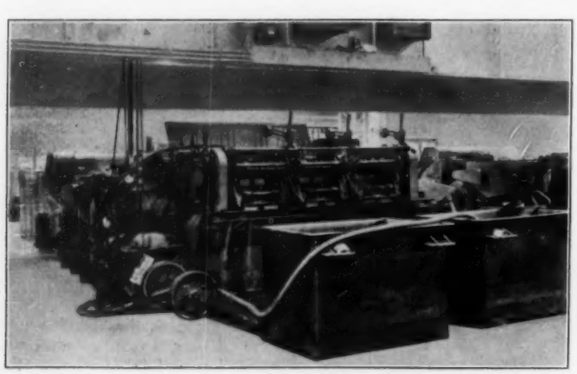
Automatic Tinning Machine

Automatic tinning machine showing adjustable speed drive.

An installation of twelve machines, some of them with rollers 72" wide and a clearance of 76", permitting the passage of three 23" wide sheets side by side. One operator tends two machines. All contamination of the sheet is avoided by keeping the pack submerged in water. The machine is automatic, the attendant only being required to introduce the pack. Each machine consists of two units, the tinning end driven by a fully-enclosed fan-cooled 3 to 1 adjustable-speed motor, the cleaning and polishing end driven by a 15 hp. fully-enclosed fan-cooled a-c. motor reducer with an output shaft speed of 205 r.p.m. This proved to be an unusually effective use of a motor reducer. A slower speed of the cleaner and polishing unit was desired than on previous installations and without expensive modifications the motor reducer filled the bill. With the reducer output shaft above the center of the motor shaft, it was possible to locate the motor below the machine, leaving the aisle entirely clear.

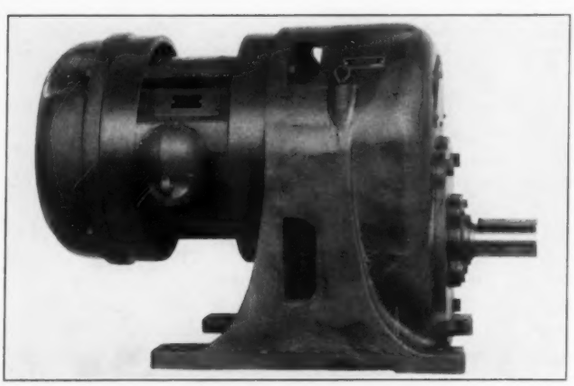
The travel of the sheets through the tinning machine is controllable from 150 to 450 inches per minute. The constant speed of the cleaning and polishing machine is sufficiently high to take care of the maximum delivery from the tinning machine.

An unusual exhaust system is installed that has proven so effective that fully-enclosed motors may prove to be unnecessary.

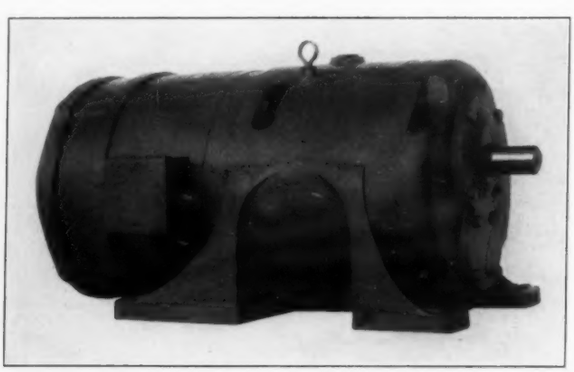


Automatic tinning machine showing gearmotor drive of cleaning and polishing section.

Automatic tinning machine showing delivery end.



Single stage A. C. gearmotor.



Fan cooled double stage gearmotor.

All wiring and control panels are located in concrete passages beneath the room, readily accessible for inspection and maintenance, and constitute an exceedingly fine installation. Control is automatic throughout with start and stop buttons at the tinning end and several stop buttons along the machine.

While the efficient exhaust system may render unnecessary enclosure of the motors, the fan-cooled type proved to be much less expensive and more compact than straight fully-enclosed motors.

Motor List

Tinning Machine
5 hp. 500-1500 r.p.m. Fully enclosed. Fan-cooled
15 hp. 730 r.p.m. Fully-enclosed Fan-cooled Gearmotor

CONTINUOUS GALVANIZING DRIVE

(To be installed in a prominent southern steel mill.)

The material to be handled is narrow strip, varying from No. 18 gauge to ⅛ inch in thickness, and the product will principally be used for beer barrel hoops. The machine is designed to handle six independent strips passing in parallel over one set of Bullers or Niggerheads to the six individual reels. Later the drive may be changed by the addition of two more strips and reels. If there is no tension on the strip, it slips over the Bullers without forward movement, so that the strips being reeled progress, while any strip not attached to its reel is stationary.

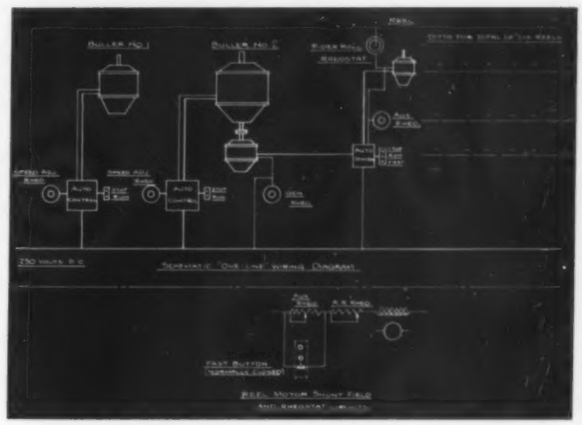
Through the use of adjustable-speed d-c. motors on the Bullers, a range of from 7½ to 30 feet per minute is available. These motors operate in substantial synchronization by adjustment of hand operated field rheostats.

Each of the reels has a direct spindle drive from a 2 to 1 adjustable-speed d-c. motor. Automatic speed decrease to compensate for the reel build up is accomplished through a rider roll, the movement of which actuates a rheostat in the field of each reel motor. Synchronization of all reel motors with the primary speed of the Buller rolls is secured through voltage control from a generator driven by the No. 2 Buller motor. The fields of all motors and the generator are excited from the main shop circuit.

As a coil is nearly wound, it is desirable to speed up that particular reel in order to remove the completed coil and clear the way for the next strip to be handled. This is cleverly accomplished by means of an extra rheostat for each of the reel motors. The pressing of a normally closed push button introduces the preset value of the auxiliary rheostat in the field of the reel motor, speeding up the reel by from zero to fifty per cent according to the presetting of the rheostat. It is evident that this speedup occurs when the rider roll resistance is nearly all cut out.

The No. 2 Buller motor has sufficient capacity to drive the variable voltage generator as well as the Buller itself.

The Buller motors are provided with push button automatic starters. Each of the reel motors has a separate automatic starter and in emergency may be operated from the mill supply line.



Electrical connections for continuous galvanizing drive.

Motor List

No. 1 Buller	1— 7½	hp.	400-1600 r.p.m.
No. 2 Buller	1—15	hp.	400-1600 r.p.m.
Reel Generator	1—10	kw. at	1600 r.p.m.
Reel Motors	6— 5	hp.	1150-2300 r.p.m.

The reel motors are very considerably oversize because of possible future requirements.

The reel generator is oversize to prevent excessive speed drop when operating at low voltage.

DROP HAMMERS

The problems in connection with motor applications on individually driven board hammers are principally mechanical. The motor is mounted at the top of the hammer and the shock resulting from the drop of the head is transmitted back to the motor. The blows may be as frequent as 20 to 30 a minute. Steel feet, well braced, are essential. Cast iron feet will not stand this service. Roller bearings are desirable. Much trouble has been experienced with crystallization and breaking of coil connectors and pole connectors. Recently several board hammers were built with the following features:

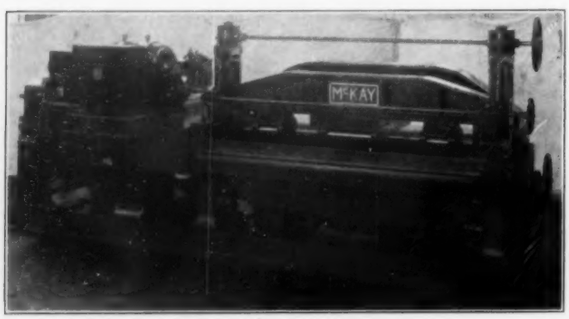
1. Steel feet, arc welded to the frame, and with a brace running across the feet.
2. All coils, coil connectors and pole connectors of special oxygen-free copper. Motor wound single circuit to give the maximum copper section. Necessary bends reduced to a minimum and all bends made on a large radius.
3. The length of the coil heads and the overhang of the pole connectors reduced to a minimum. All pole connectors and coil heads thoroughly laced and dipped in a special varnish to assure rigidity.
4. Roller bearings.
5. Cast aluminum rotors.
6. Steel spiders.
7. Lock washers used throughout.

Installed some months ago these motors have been less free from failure.

BUDD-McKAY SHEET PROCESSING MACHINE

This machine is used in processing automobile body and fender sheets immediately before drawing and punching. The cold rolled sheets, as received from the mills, are not entirely free from strain areas,

which may result in tearing during the drawing, or surface blemishes which are apparent after ducoing. As the sheet is fed into the machine it is gripped by a pair of pinch rolls driven through an over-running clutch. Passing above the depressed processing roll the sheet enters another pair of pinch rolls. The top roll of this pair is raised by the thickness of the sheet, and this movement is multiplied through a clever mechanical leverage system to close the switch in the circuit of the motor which elevates the processing roll. This upward movement of the processing roll carries it above the level of the pinch rolls, forming an inverted U in the sheet, drawing the necessary material through the entering pinch rolls, which are permitted to speed up by the over-running clutch. Beyond the second set of pinch rolls is a roller leveller, through which the sheet passes.



Sheet processing machine—entering side.

Sheet processing machine—delivery side.

Every part of a sheet is thus thoroughly processed and delivered from the leveller rolls flat and entirely relieved of all strains. Experience has demonstrated that to be most effective, this processing must precede the drawing by not over two or three hours. In practice the processing immediately precedes the drawing, the machine being located directly in front of the presses.

The roller leveller and both sets of pinch rolls are driven by a four-speed, constant torque, squirrel-cage motor. The speed at which the machine is driven depends upon the thickness of the sheet being processed. A small, motor driven pump sprays oil on the rolls during the processing operation.

Hatchway limit switches control the extent of travel of the processing roll. When the sheet completes its passage through the second set of pinch rolls the processing roll is automatically returned to the lower position so the next sheet can be entered.

The control panel provides for automatic, leveller, or foot operation. Under the first condition the processing roll automatically is raised and lowered as previously described. No attention is required from the operator other than to feed in the sheets. Under the second condition the machine operates as a leveller only. Under the third condition the processing roll is under the control of a foot switch and is operated when necessary.

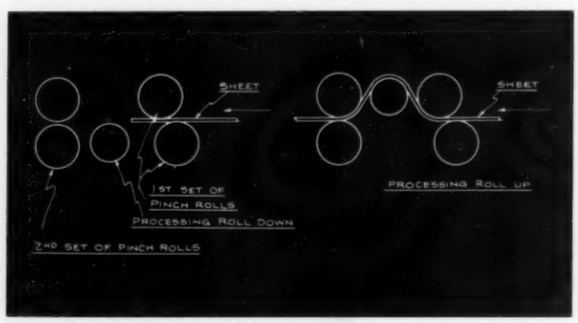
To reduce to a minimum the portion of the sheet not processed, exceedingly rapid upward movement of the processing roll is desirable. Equally rapid downward movement is desirable to permit the entrance of the next sheet with a minimum of delay. The processing roll is elevated in a fraction of a second, only two and one-half revolutions of the motor being necessary for the full travel of the roll. The same is, of course, true for the downward movement. The drive requires a motor with a high starting torque, capable of accelerating very rapidly. A special low WR^2 rotor is used. The brake wheel which is mounted on a motor shaft is also specially designed to have a low WR^2.

The equipment handles sheet up to No. 16 gauge and permits the passage of a sheet ninety inches wide. The sheet passes through the machine at the rate of 120 feet per minute when the four-speed motor is operating at its high speed. The machine was originally designed to handle ten sheets per minute but its operation has been so successful that twenty sheets per minute is not unusual.

On several machines designed to handle ten sheets per minute the elevating motor proved inadequate when the output was otherwise successfully pushed up to twenty sheets per minute, requiring forty starts and stops of the motor which raises and lowers the processing roll. Space requirements prevented the use of a larger and more liberal motor and the use of a water-cooled motor was decided upon. The water-cooled motor successfully handles the 100 per cent increase in the starts and stops. Later machines designed for operation with twenty sheets per minute are using a 450 r.p.m. motor, whereas the original machines use a smaller motor at 720 r.p.m.

Motors:

Main drive for pinch rolls and levellers.
40 or 50 hp., constant-torque, 1750, 1150, 860, and 570 r.p.m., squirrel-cage motor.
Processing roll, elevating drive, special torque motor; 720 r.p.m. for ten sheets per minute, and 450 r.p.m. for twenty sheets per minute.



Sketch showing sheet before and after elevation of processing roll.

WATER-COOLED MOTORS

For certain special applications the use of water-cooled motors in the steel mills seems to be a logical development. Heat may be removed from the inside of a motor exactly as it is removed from the cylinders of an automobile engine. So little water is required to cool an electric motor that it is desirable to take the water from the plant supply rather than to provide a closed system with a cooling radiator.

In an open motor air cooling is so simple and effective, the cooling medium reaching all exposed parts of the core and windings, that it will probably never be replaced. In the case of an enclosed motor, however, the dissipation of the heat by pipe ventilation, or even outside fan cooling, is so much more expensive that water cooling may well be considered. This is particularly true where the losses to be dissipated are large compared with the size of the motor, such as in high slip motors and motors which are frequently started and stopped.

The heat absorbing capacity of water is 3500 times that of an equal volume of air for the same increase in temperature of the cooling medium. In other words, it requires 1122 heat units to raise 1 cubic foot of water 10° C. and only .32 heat units to raise 1 cubic foot of air by the same amount. Numerous tests have demonstrated that to maintain a water-cooled motor at 55° C. temperature rise .1 gallon, or .0134 cubic feet, of water is required for each kw. of loss. If air was used as a cooling medium instead of water, and if the temperature rise of the cooling air was the same as the cooling water, we would expect to require 3500 times .0134, or 47 cubic feet air per minute for each kw. loss to maintain an air cooled motor at 55° C. temperature rise. Due to the less intimate contact of the air with the parts to be cooled the temperature rise of the cooling medium is less than it is when water is used for cooling with the result that to dissipate the same amount of heat, proportionately more of the cooling medium must be used. Instead of the 47 cubic feet of air per minute per kw. loss which might be expected, it is found that in a pipe ventilated motor, where the air is blown through the motor rather than over the surface, it is wise to provide a minimum of 100 cubic feet of air per minute per kw. of loss to maintain a motor at 55° C. temperature rise. Summarizing, to maintain a motor at a 55° temperature rise requires .0134 cubic feet of water per minute per kw. loss in a water cooled motor and 100 cubic feet of air per minute per kw. loss in an air cooled motor.

As an example of the effectiveness of water cooling, a 5 hp., 1800 r.p.m. motor, with core and windings duplicating an open motor, has been operated at 50 per cent overload without exceeding a temperature rise of 40° C., by passing a sufficient quantity of water through the frame. This is cited as an interesting illustration. Such overload operation should not be contemplated regularly, as the motor is not designed for it electrically or mechanically.

In a fully enclosed motor all of the heat dissipated must pass through the enclosing metal parts. The same is true of a fan-cooled motor and a water-cooled motor, but in this case the heat is picked up from the surface and carried away by the cooling medium. As pointed out earlier in the paper, water much more effectively picks up the heat from the surface than does air. Both the water-cooled motor and the fan-cooled motor represent a lower first cost than the fully enclosed motor, but both of them must be charged with the supply of their cooling medium. In the fan-cooled motor this is represented by power required to drive the fan and in the water-cooled motor by the cost of supplying the water to the motor.

Water-cooled motors are particularly effective when the surrounding atmosphere is at high temperature. The water-cooled stator acts as a jacket protection against the high outside temperature, as well as a means of efficiently and economically removing the heat generated in the motor itself.

Water cooled A. C. motor.

The cast stator frame is cored out for the water passages as is the cylinder block of an automobile engine. The walls enclosing the motor are solid without gasketed joints and leakage to the inside is impossible. Excepting when the surrounding temperature exceeds 60° C., water cooling of the end bells or brackets is unnecessary. Unless the motor is located where there is no danger of freezing, provision should be made for a valve at the bottom of the motor for completely draining the stator frame. There should be no more rust and deposit than is found in the cylinder block of an automobile engine. Plates for inspection and cleaning add but little to the cost of the motor.

The danger of condensation within the motor is present the same as it is with all fully enclosed motors. Provision should be made for draining the inside of the motor through a plug at the bottom.

Suitable protection should be included in the control to prevent the motor from operating should the water supply fail for any reason.

While the use of water cooled motors in the mills should be considered to be in the experimental stage, such a type of motor may well be considered for applications where the windings must be totally enclosed, where the surrounding temperature is high, where unusual service demands, such as frequent reversal, result in large losses to be dissipated, or where space is limited.

Discussion

▲

Discussion presented by

W. E. Miller, Electrical and Mechanical Supt., Bethlehem Steel Company, Johnstown, Pa.

J. Farrington, Electrical Supt., Wheeling Steel Corporation, Steubenville, Ohio.

G. E. Stoltz, Manager, Mining and Metal Working Electrical Industrial Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

A. J. Standing, Electrical Supt., Bethlehem Steel Company, Bethlehem, Pa.

H. A. Winne, Ind. Engr. Dept., General Electric Company, Schenectady, N. Y.

J. C. Reed, Electrical Engineer, Bethlehem Steel Company, Steelton, Pa.

A. M. MacCutcheon, Engineering Vice President, Reliance Electric & Engineering Company, Cleveland, Ohio.

W. E. Miller: Mr. MacCutcheon's paper has brought to my mind the thought that we should use the same care in applying motors to most of our steel mill drives that he has demonstrated to us in the application of motors to these unusual drives. We often apply a motor to a job just because it happens to be handy in surplus, and we are no doubt paying a heavy penalty for this practice. I feel we ought to look a little closer into the characteristics of motors we use from day to day and get the right motors on the right drive.

We would like to hear from anyone present who has anything to say about this paper. We would like to hear from Mr. Farrington.

J. Farrington: We attempt to cool our motors by applying water from the outside rather than circulate it on the inside. We have designed some motors to carry a heavy over-load by applying the water on the outside. We will be interested in seeing which of these two systems prove the best.

G. E. Stoltz: I would like to make a suggestion that some of the auxiliary drives require more study than the application of the primary motors. I don't know whether I understood Mr. MacCutcheon in his definition of primary and secondary drives and their problems but some of the secondary drives really require more attention than the primary. I have in mind some of the applications described by Mr. R. H. Wright in his paper presented at this convention such as the use of a motor on a flying shear.

We have spent more time and had more difficult problems to meet on some of the auxiliary drives than on the main drive applications.

I want to sanction Mr. MacCutcheon's idea that some of these require a great deal of attention. I would not label them for secondary consideration or of a secondary type; I would give them a primary position. Often the operation of the small motors must be synchronized with the mill proper.

We have attacked the problem of cooling some of these small motors a little differently from what Mr. MacCutcheon has. He raises the question as to why not give the small motor as much ventilation or give it cooling air the same as we do in main drives. It is becoming customary in some of the large continuous mills to provide artificial ventilation for the main motors. One of the reasons we ventilate the large motors is that we invariably and frequently operate over a fairly large speed range, and if the fans on the rotor are designed to properly ventilate them at top speed they don't get much air through them at a slow speed.

In developing fan-cooled motors, the smaller machines have the fan on the outside. The air flows then through the frame or through cored holes in the frame. On larger machines we found a practical design could not be based on that type of ventilation and a frame casting was provided with a series of cored holes through the entire circumference. A blower was added to cause a definite circulation of the air inside through alternate cored holes in the frame, and then the fan on the outside of the motor drove air through the other half of the cored holes. We have a definite circulation inside and a definite circulation outside, and the air from these two systems being driven through alternate ducts in the frame. This effected a very pronounced increase in rating of motors.

A. J. Standing: I will agree with Mr. MacCutcheon and Mr. Miller that we should go into the application of small machine drives with a great deal of care. I want, however, to point out the fact that when the N.E.M.A. motor came to the steel trade we thought the millenium was here as far as interchange of motors and mounting and duplication of spares and space; and now the motor manufacturers have begun to develop entirely special motors for special applications and N.E.M.A. rating is entirely shot, which means we have special machine tools and an assortment of entirely odd motors to maintain. We do not always have the latitude we would like to have in the selection of electrical equipment on some of these machine tools.

An expression that Mr. MacCutcheon used is very apropos. He said, the "machine tool motor is tucked in somewhere." We know the motors are tucked into machine tools and I think the time has come to untuck some of them. Machine builders hide them away without the least regard to their accessibility when they have to be overhauled, and when you tuck the motors inside the machine tool they introduce inherent vibration in the machine itself, which is transmitted into the tool and sometimes is injurious to the product. Even if the original motor is perfectly balanced when the original application is made, a rewind of the armature in our service shops may very materially effect the subsequent balance and result in increased machine vibration.

The drive for greater portability of machine tools is largely responsible for this modern built-in drive.

H. A. Winne: I want to endorse Mr. MacCutcheon's and Mr. Stoltz's remarks to the effect that what Mr. MacCutcheon terms the secondary auxiliary drives, deserves real engineering attention. This applies not only to the motors, but to the control as well. Very often the control on these small drives involves more real complication and causes us more headaches than does that, for example, on the 7000 hp. reversing blooming mill drive.

As regards adjustable speed motors for some of these special drives, I think we should not lose sight

of the fact that the mill type auxiliary motor is available for adjustable speed service. This type of motor, with which we are all familiar, and which has such a wonderful service record under severe conditions, can be equipped with shunt fields which will permit a range of speed by field control of approximately 2½:1. The adjustable speed mill type motor is finding a great many applications in modern mills, particularly in connection with the continuous types of mills, for table drives, etc.

Mr. MacCutcheon mentioned a desire to see provision made for ventilating auxiliary motors by means of connecting them up to an air duct extxending through the mill. Such provision is being made in a number of the more recent mills, and it proves a very efficacious method of keeping the motor thoroughly clean, and also getting more output from it. You can take an enclosed mill type motor with a 1-hour rating of 35 hp., and by putting sufficient air into that motor, you can get 35 hp. continuously without overheating.

There is one point that must be borne in mind, and that is, while piping air to the motor will permit increasing its continuous or time rating, it does not increase the maximum peak capacity, which is limited by commutation. But even where the size of the motor is determined by its peak capacity, piping air to it ensures that it will be kept clean, i.e., assuming that the air is filtered.

There is one installation going in at the present time in which air is being piped to the motors, but there will be no air outlet from the motors, the idea being simply to keep sufficient air pressure in the motor so that there will be no ingress of dust or foreign matter, even through the small holes provided for lubrication in the bearings. In other words, it is expected to keep the motors spotlessly clean.

J. C. Reed: I have enjoyed Mr. MacCutcheon's paper very much and am interested in the water-cooled motor. The idea is by no means new, but heretofore there has never been a motor manufacturer who was willing to bring out a line of motors of this type, due to the fear that there would not be sufficient market for them. There is, however, a limited market for motors of this type and I have many times wished for a water-cooled motor.

In the steel industry we are called upon frequently to install motors in locations where the air temperature is so high that we must resort to some means of cooling the motor, and the simple and convenient means of turning compressed air on, or into the motor, is used. In some cases the motors are totally enclosed and a fan is used to bring air through a pipe to the motor. This is usually an expensive as well as a troublesome installation and reasonably clean air is not always available. Then again, in case of a short or a bad flash in the motor there is danger of the motor getting on fire and the presence of the air increases the fire and one has a miniature blast furnace which totally destroys the motor. A water-cooled motor has none of these objections and I believe they will come into common use as soon as they are made available.

I wish to thank Mr. MacCutcheon and his company for taking this progressive step.

A. M. MacCutcheon: I was greatly interested in Mr. Stoltz's comment on cooling a motor with a fan not running at the same speed as the motor. Apparently our thoughts have run along parallel lines, as we have developed a similar application. Mr. Hough has described a water-cooled motor used for elevating a processing roll where there are 40 operations a minute. On another application, where the duty was equally severe, a fan-cooled motor was used with the fan independently driven by a small motor, the motor and fan mounted on the end bracket of the motor. The fan was continuously running, even though the motor was stationary. The control was so interlocked that the main motor could not operate if the fan motor were not running. Since the main motor makes but two and a half revolutions in each operation, a fan mounted on the shaft of the main motor would be of no value. This application worked out very satisfactorily, as did the application which Mr. Stoltz has described.

The most remarkable feature of a water-cooled motor is the very small amount of water necessary to accomplish the cooling. If a fan-cooled motor is charged with the electrical power necessary to operate the fan, water-cooling will, undoubtedly, prove to be more economical.

Mr. Standing has commented on our departure from N.E.M.A. standardization. This comment is an excellent one. In developing these special motors there is some departure from the N.E.M.A. standardization. I believe that there will always be motors built for special applications which will differ from standard motors. However, in making special motors, such as water-cooled motors, N.E.M.A. dimensions form the basis from which we work, and a large amount of interchangeability still remains. In fact, the water-cooled motors which we have made have the same mounting dimensions as the standard N.E.M.A. motor. I feel that the industry is much better off than it would be had the N.E.M.A. standardization not been accomplished. In the case of the water-cooled motor the water-jacket simply takes the place of the air-jacket, and does not increase the mounting dimensions in any way.

As regards making a d-c. motor water-cooled: In the case of the d-c. there is one difficulty not present on an a-c. The d-c. frame is of either rolled or cast steel. It is much simpler to secure a casting with water passages cored in in cast iron than in steel. Cast iron is that material least affected by impurities in the water. I would not say that it is impossible to make a d-c. motor water-cooled, but it is more difficult. I feel that the making of a water-cooled motor could be accomplished through the use of a cast steel frame, also through the use of a welded steel frame. The expense will be a greater proportion than in the case of an a-c. motor. It is not, of course, impossible to use a cast iron frame on a d-c. motor of a much greater magnetic section.

There is one point covered by Mr. Hough which I would like to further emphasize. There is no opening from the water passages to the inside of the motor. Gaskets are not depended upon to exclude the water from entering the motor. The cored passages through which the water passes are separated from the inside of the frame by solid cast iron walls. Castings are secured with close grain and are carefully inspected against any possibility of defect which would permit entrance to the inside of the motor by the water.

Mr. Farrington's discussion brings to my mind an installation that is soon to be made in one of the steel mills. The motors being supplied have cast frames with cored openings for the circulation of water, and four covers approximately 90° apart. The motors are to be installed on a coiler. It is very desirable to keep all of the motors interchangeable, which accounts for the four covers. In any one of the mounting positions one of the covers comes approximately at the top, and another approximately at the bottom. The motors may operate as straight fully-enclosed motors, as motors cooled by a splash into one of the cover openings draining from the opposite opening, or as true water-cooled motors with the mill water carried to the motor frame under the mill pressure. If it is desired to operate the motors as straight fully-enclosed motors the proper covers will be removed from the motor so as to permit of a circulation of air through the passages provided for the water-cooling.

The permissible rating with the water-splash will be 50 per cent greater than as a straight fully-enclosed. The rating with the mill's pressure applied and a controlled amount of water passing through the frame will be two and one-half times the fully-enclosed rating. If the duty imposed on the motors does not exceed the rating of straight fully-enclosed no water will be supplied. If experience shows the necessity for an increased rating splash will be directed into the cored passages. If for extreme conditions of operation a still higher rating is necessary, the mill water pressure will be connected to the motors.

I do not feel that water-cooled motors will be used excepting on special applications where there is a very high surrounding temperature, or where there is an excessive loss within the motor due to frequent starting and stopping, or under somewhat similar conditions. However, I believe there is considerable opportunity for installing such motors in steel mills to the advantage of the user.

W. E. Miller: When the water-cooled motor is mentioned, at first thought one thinks of the fact that water and electric currents usually have detrimental effects when mixed.

Safe Maintenance Work On Industrial Electrical Equipment

By J. D. DONOVAN,
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Presented before the National Safety Congress held in Cleveland, Ohio, October 1 to 5.

J. D. DONOVAN

It is with a distinct feeling of pride that I exercise the privilege of taking part in this meeting of your worthy organization, the National Safety Council. Such pride is surely justified by your excellent record in accident prevention, but there is a secondary source which may perhaps be best indicated by quoting the words of one of your former vice presidents, Mr. H. A. Renninger: "The National Safety Council looks upon the Association of Iron and Steel Electrical Engineers as the god-father of the Safety Movement in America—for, as you will remember—it was by the members of your own group and at your 1912 Convention, that a nucleus of safety leaders first conceived the idea of organizing a National Association to study the national accident prevention problem and establish a clearing house of information for safety in the workshop, on public highways and in our homes. It must be a source of great pride to the members of the Association of Iron & Steel Electrical Engineers to observe the growth of your god-son." Let me assure you that it is a source of great pride to our Association to observe our son's development.

The Safety Movement, whether it be in a steel mill, on a railroad, or elsewhere, is a great creation; in fact, it is one of the greatest creations that the world has ever known, as it affects every man, woman and child in the world. There are many great things in the world but very few that reach and concern all the people. The beginning of Safety was manifested to us by the Creator of the world in the creation of man—in the location of the senses, which were developed to an acuteness to suit the occasion.

Today, as a general rule, in all lines of industry, safety has become as much a part of the business as any of the production methods. We therefore see

safety devices of all kinds and description to permit the various manufacturing operations to proceed without personal injury to the operators. Careful consideration has been given to the selection of equipment, application of guards and safety appliances, which automatically keep those employed in straight production work within the confines of safety.

With the man employed in maintenance work we have quite a different proposition. Usually to get at the seat of trouble or do some repair job, he must tear down or remove the safety equipment provided for the production employee and must personally provide for his own safety. This is especially hazardous around electrical equipment because the presence of potential does not register on the senses of sight, hearing or smell. When we feel it, the damage is done.

It is therefore imperative that men employed in electrical maintenance should be of the highest type, especially trained for this kind of work—not only how to do it, but should realize the dangers present. In order words, the personal element is very greatly involved in the safe conduct of this class of work.

The subject—"Safe Maintenance Work on Industrial Electrical Equipment"—is one that merits serious consideration, for there is no branch of industrial maintenance that presents the same hazards to severe injury as is found in work on electrical equipment and installations.

The generation, transmission, distribution and utilization of electricity is accompanied by a considerable hazard to humans from electric shock, commonly termed the "shock hazard." Perhaps the first "shock hazard" on record was experienced by Benjamin Franklin when he touched the key on the string of his classic kite. Since the harnessing of electricity to the service of mankind, its development and application multiplied the hazards so rapidly and greatly that our practices required constant revision. Our ideas were necessarily kept more or less in a state of flux— a situation which must also be met today by our industrial leaders in meeting current business conditions.

Even a slight shock, while not in itself harmful, may at times result seriously by causing the workman to loose his balance while working in a dangerous position, or to cause a sudden and uncontrolled movement of some part of the body, which may result in bringing tools or parts of the body into contact with live parts of a circuit, which may present a more serious hazard. The shock hazard naturally falls into two groups: High voltage and low voltage.

The high voltage hazard is the result of the possibility of the higher voltages of a transmission or distribution system being imposed upon the low voltage wiring systems, due to the breaking down of a transformer, the crossing of high and low tension wires, etc. This dangerous condition exists only under abnormal conditions, but while such conditions do not occur frequently, they are, of course, very serious when they do exist.

In the larger industrial establishments, which have transformers installed on the premises, the chance of a cross between a high and low tension wire is reduced to a minimum. The low voltage hazard, however, is much more serious due to several factors, perhaps the principal one being the use of portable tools, hand lamps, etc., under conditions where a breakdown of the insulation is almost sure to result in a more or less serious shock owing to the good conductive conditions which generally prevail. In our experience during the past several years there have been more serious accidents from low voltage than from high voltage. This would lead us to the conclusion that not enough serious attention is being given to the low voltage hazard. It is our opinion that a great deal of consideration and attention should be given to this particular phase of electrical maintenace.

The problem of operating and maintaining high voltage equipment and overhead electric lines from the standpoint of man-safety is similar to that of any other safety problem. It is peculiar, but true, that the accident ordinarily occurs from what is commonly considered to be a non-hazardous situation; for the problem that presents the known hazard is very carefully thought out. It is checked and each situation fully covered and preventative action taken. The workmen themselves under this situation are highly alert during the progress of the work because of its unusualness. A thorough, full and detailed knowledge of all the hazards that make up the problem is therefore required and it is apparent that care and attention to detail is the essence of working safely.

In the other case where situations are such that practically no hazard is apparent, the detailed checking may be either absent or loosely performed, and the workman goes into a situation in which he is either ignorant of the hazard, or if a hazard is present and it is apparently of a minor nature, there is lack of concentration on the hazard because it is a minor one.

Fundamental principles that relate to efficiency and safe operation of electrical equipment are fairly well understood. The full application of them is neglected not so much because of lack of knowledge as because of lack of capital in some cases, and fear to invest it in others. Nothing has ever been done toward making electrical equipment more efficient that did not result in making it more safe, and nothing has been done to make it more safe that did not result in higher producing efficiency.

The accident prevention problem involves two essential elements—"Safeguarding and Education."

In the application of safeguards there are two thoughts to keep in mind. The first thought is the protection of the workman; the second is the output of the mill; taken together they constitute the proper application of an efficient safeguard in relation to production. In safeguarding electrical apparatus we find one of the most difficult problems to safeguard is familiarity—"Familiarity breeds contempt." At one time it was the opinion of many that safeguarding equipment and providing means for operation believed to be safe, would have no perceptible effect in lowering accident records, but results go to show the error of such an assumption. Credit is given to both safeguarding and educational training. Methods and rules set up today in all progressive industrial plants tend to cut to a minimum the chance of accident in maintenance work on electrical equipment. This is true for mechanical as well as electrical maintenance men.

Naturally one of the first considerations in safe maintenance work is in the original installation of

equipment. No doubt the frequency of accidents involved in maintenance is in proportion to the man hours spent on this kind of work. Therefore, by careful selection and installation of approved equipment, we naturally lessen maintenance and the hazards which accompany it. Manufacturers of electrical equipment have done much to help industrial safety by incorporating safety features in their products. With the expanding of the application of electrical power in all industries more men are continually being subjected to certain hazards connected with its use. For this reason it is now very important that new installations be made with only approved safety electrical equipment.

It is the general opinion of safety engineers that all electrical apparatus be enclosed so that only authorized persons can possibly come into contact with current carrying parts. No open wiring is permitted. The electrical engineer in the steel mill has a different problem because every piece of electrical apparatus that is installed must be done in a manner that will permit ready removal in case of trouble. It must be accessible for inspection and repairs, and at the same time meet the safety requirements. Motors must be installed so that the whole motor may be removed quickly in case of motor failure and at the same time comply with the safety requirements by not having any exposed wires. Mills built previously to the days of rigid safety demands were not constructed so that all the most approved methods for safety could be applied. However, you will now find that practically all have met present day safety requirements.

In connection with new as well as old electrical installations a very important safeguard is safety locks. Too much stress can not be laid on the conscientious use of safety locks. We are of the firm opinion that this is one of the greatest safeguards we have in connection with electrical and mechanical maintenance work, especially in the steel mill. Its great advantage is fully realized in our work and great emphasis is placed on it in our safety education. Hasps for safety padlock are now standard equipment on low voltage enclosed safety switches. The steadfast rule should be made that no mechanical or electrical repairs, regardless of how trivial, can be made unless each craft working on the job has placed a safety lock, locking the power feeder open on the switch. In days gone by it was felt safe to have a control switch to lock open when men were working on some electric driven equipment. Due to the possibility of grounds, shorts, or contactors sticking, this method of protection has proven inadequate and in many plants entirely discarded. If the employer is willing to take the additional delay caused by taking time to lock out the machine, why should the man not take this safeguard afforded him? If the main power feeders are manually opened and locked open, the machine cannot start. This same precaution should also be used on high voltage lines and equipment, as will be discussed later.

The list of accidents directly chargeable to switches, that is burns and shocks from contact with live parts of switches, is a very long one. The list of accidents chargeable to unexpected closing of switches is also a very long one and the results are usually more serious than from contact with parts of switches. The contacts may result in burns or shocks; closing unexpectedly may result in running machinery over persons, crushing them between moving parts, entangling them in gears or belts and numerous other things injurious to persons and property. While we might consider that burns or shocks from direct contact with parts of a switch are not often serious and could be avoided by using a reasonable degree of caution, the fact is that they do occur and most frequently with those who might and do know they should exercise caution. Some of the burns from flashes are on the eyes and it is not uncommon for the result to be total loss of sight, an affliction that ranks with the most deplorable that can result from accidents.

In working with electrical equipment, one all important general rule should be rigidly enforced—"OPEN BREAKER AND DISCONNECTS"—in our opinion highly important. All main oil switches should be interlocked with disconnects so that it is impossible to open disconnects without first opening the oil switch. This interlock can either be mechanically or electrically operated, or a combination of both. To merely open an automatic oil breaker is not a sure way of preventing its closing. The normally operated disconnecting switches must be opened and either the cabinet enclosing them be locked or else the blades themselves be tied and locked out. In this operation there is again danger of opening disconnects under load. This is eliminated by interlocking the oil breaker with the disconnects, either mechanically or electrically, in order that blades cannot be opened unless the oil breaker is open. There have been many serious accidents as the result of opening disconnects under load. Every precaution must be taken to prevent such opening: First, for the safety of the operator who has to open the switch; and Second, to prevent the serious breakdowns which may develop from the arc created by the opening.

On the smaller systems, where the smaller switches are adequate, mechanical control through levers operated by hand is perfectly practicable. In the large systems the main oil switches are so heavy as to make manual control impracticable, and it becomes necessary to close and open the switches by means of electrical power. This introduces in place of the simple direct hand control, a more complicated electric circuit in which the storage battery, relay and trip coil are the more important elements. When it becomes necessary to operate one or more breakers in a substation electrically, there are advantages in electrical operation which more than offset the difficulties involved in the additional complication and make it very desirable that all of the switches in the station should be electrically operated. The two most important advantages derived from electrical operation are: 1st, Safety, and 2nd, Flexibility of Automatic Control. Through electrical operation only low voltage circuits are on or near the control board which the operator handles. All of the primary or high voltage circuits are located at a distance from the operator, thus eliminating the possibility of the operator coming in contact with live parts in his routine work or from suffering injury due to breakdown.

Emergency switches, often called safety devices, are usually remote control devices and should not be trusted to protect a man while working on equipment.

Emergency switches are also employed as safety stops. Here we have the possibility of failure due to grounds, etc. Such switches should be tried out daily if they are to be depended upon. Generally speaking, emergency switches should be inspected and operated at frequent enough intervals to insure their positive operation in event of emergency. The hazard involved and atmospheric conditions would be the controlling factors.

It may be well to list the tools that should be available at all substations for the safety of the electrical maintenance men.

1. Disconnect poles of the various lengths required should be provided. Incidentally these poles should be kept in a location where they will be positively dry at all times and must be well shellacked.
2. Disconnect lock outs are a part of the substation safety equipment.
3. Voltage indicators for testing high voltage lines and conductors before applying grounds are important.
4. Ground chains and sticks, provided with clamps to insure ready and positive connection to ground, should be available together with dry hand lines.

Each maintenance man should be provided with goggles, safety lock and belt as part of his personal safety tools. Careful inspection of safety belts at regular intervals is important.

Hand tools should be well selected and maintained to insure safety. Good tools should be used as many accidents have been caused by using poor tools or using a wrong tool on account of proper tool not being available.

Clothing and shoes should be watched carefully to avoid trouble. The clothing should be dry and free from excessive amounts of inflammable materials, and should be as close fitting as possible. For line gangs doing maintenance work in wet weather, rain coats, hats and rubber gloves are important. Shoes should have good soles properly fastened, as a loose sole is a dangerous hazard. Safety shoes should be worn. A safety shoe for an electrician should be free from any metal and should, of course, carry an insulated sole. Non-slip soles are very desirable.

The educational side of any safety work is very important. Providing safety rules for guidance of employees, in order that they may do their work in a manner that accidents will be avoided, is a subject that has been much discussed by persons interested in safe guarding employees. No doubt, as one looks back to the inception of electrical equipment generally and compares the accident records then and now, it is surely gratifying to note the strides that have been made in safety as regards electrical maintenance work. Your Council, as well as all others responsible for this great work, are to be sincerely congratulated and encouraged to continue this good work.

As for methods and safe practices to be employed to prevent injuries from high voltage equipment, all plants set up their own rules. The power companies have their rules for working on such equipment and so do the steel mills. To attempt to set up a standard set of rules that would be applicable to all plants is out of the question. What we will enumerate on high tension rules are those which seem to have general prevelance.

1. Working on high voltage lines or equipment. Anyone who is required to work on High Voltage (Defined as 440 and higher) must get in touch with the Electrical Foreman, who will see that all proper precautions have been taken for the protection of workmen. The Electrical Foreman will be entirely responsible for clearing the line, and for the safety of the men.

2. Opening breaker and disconnects. Before men work on high voltage lines or equipment, breaker must be opened and disconnects must be opened at both ends of line or equipment and properly protected by lock or other means to prevent anyone from throwing same in while men are at work on lines or equipment.

3. Grounding. Before starting work on high voltage lines, all conductors leading to the point where work is to be done must be tested with voltage indicator, grounded and shorted on both sides of the point where work is to be done. Standard ground stick or chain is to be applied, first to the ground connection, then to conductor as close to point of work as possible. Ground chains must be pulled across conductor with dry hand line.

4. Clearing the line. The Electrical Foreman must assure himself that every man is off the line before removing grounds, and all grounds must be removed before disconnects are unlocked.

5. Restoring power. The operator in charge of equipment which was shut down must be notified by the Electrical Foreman who was working on lines or equipment when same is clear for restoring power, or by foreman in charge of work if same carries on beyond the time of work of the man giving original notification.

6. Exposure to High Voltage Lines. No workman or group of workmen will be permitted to work, carry tools, material or equipment on or about any building, roof, pole or tower where he or they may be exposed to the possibility of contact with a high tension line, without the knowledge and approval of the Electrical Foreman of the particular department. Sufficient advance notice should be given in order to insure proper planning and execution of the work.

7. In order to prevent accidents through misunderstanding, operators in charge of equipment receiving unwritten messages or instructions shall repeat them back to the sender. Persons issuing such unwritten messages or instructions shall require the receiver to repeat back to him such instructions. The sender and receiver of such messages should secure the full name and title of the other party.

8. Foreman in charge of workmen having work of any nature to do which will expose them to such a hazard, will contact with the Electrical Foreman in charge of the department in which such work is to be done and will not proceed with the work in hand until advised by him to do so.

9. If, in the opinion of the Electrical Foreman, the location of the work is of such a nature that there is a possibility of the men making a mistake and blindly moving into adjacent or overhead live lines or equipment or placing any of these workmen in danger through contact with such lines, he will designate an experienced man to stay with and guard

(Continued on page 462)

Nitrogen In Metallic Arc Weld Metal

By DR. J. W. MILLER
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IN hereby presenting Dr. Miller's paper, which was delivered before the A. I. & S. E. E. at its 30th Convention held in Cleveland, Ohio, September 18, 19 and 20, 1934, and which is an abridgement of thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Science in Metallurgy, Massachusetts Institute of Technology, it is being prefaced with a short review by Dr. P. P. Alexander, Thomas Research Laboratories, General Electric Company, Schenectady, N. Y.

More than three-quarters of the atmospheric air consists of nitrogen, therefore, it is very necessary to know how this element affects welding, and perhaps it will be useful to review briefly what steps were gradually taken during the development of the art of electric welding to bring under control the powerful effect of that gas on the welds.

Metallic arc welding was originated in 1890 by H. Slawianoff. Being a metallurgical engineer with a thorough knowledge of electrical engineering, he was able to appreciate the electrical as well as the metallurgical side of electric welding. In a short time he was able to develop arc welding to a high degree of practical perfection, and under his direction it was used on production work. An automatic arc welding machine of his design was put into use in the factory for welding steel and even copper pipes. Furthermore, adequate fluxes for each type of material were used since he was using a welding current ranging from 600 to 800 amperes. With his untimely death, the work was stopped, and arc welding in Russia became a lost art. However, this work was again taken up, especially in England, and soon developed into a fine art of arc welding with fluxed electrodes and comparatively low currents of 100-150 amperes.

In this country arc welding achieved general development during the World War. Many concerns answering the requests of the war needs (especially in the field of rapid construction of the amergency fleet of transport and cargo vessels of every kind) soon adapted the art of welding to local conditions and evolved a system of welding with bare electrodes.

This change from the fluxed electrode to the bare wire electrode system was due to two factors:

1. Because accurate tests indicated that there was no appreciable difference in the quality of the welds produced with the fluxed electrodes available at the time, and welds made with a good grade of bare wire.
2. Electrical engineers were soon able to develop such arc welding generators as would give a perfectly stable welding arc without the additional stabilizing effect of the flux.

This American system of welding with bare electrodes is entirely satisfactory for many purposes, and for many years it was used almost exclusively in this country.

As time passed, electric welding was continually extended to the fields where welds had to possess, not only strength, but also high ductility, resistance to shock, corrosion, etc.

Metallurgists discovered in arc welds the presence of nitrides of iron which exerted a powerful effect on the quality of the weld. Nitrogen in welds increased to a certain extent their tensile strength, but at the same time reduced their ductility.

Pioneer work in this field was done by S. W. Miller of the Rochester Welding Works and W. E. Ruder and G. R. Brophy of the General Electric Company. Later it was taken up by other investigators, among whom were the Bureau of Standards, Dr. Hensel of the Westinghouse Company and finally Dr. J. W. Miller.

The presence and the effect of nitrogen on the welds was established. It was now a problem of controlling, and when necessary, of counteracting the effect of nitrogen. Here again the American metallurgists and electrical engineers made a notable contribution to the art, and in fact brought it to such a state of development that it can now be used on such structures as high pressure vessels, certain parts of steam turbines, gun carriages and other articles used in ordnance or naval constructions which are subjected to high pressures, or alternating stresses and repeated shocks.

One system of protection from nitrogen consists in surrounding the arc and the weld by an envelope or a jet of hydrogen gas. The well-known Atomic Hydrogen Process is one of the methods of eliminating excessive amounts of nitrogen in the welds. Another system of protection consists in providing the electrode with a heavy covering of flux which eliminates to a considerable extent the possibility of contact of the surrounding nitrogen with the arc and the weld.

Pioneer work in developing and applying this system to the welding of heavy pipes and pressure vessels on a large scale, was done by the A. O. Smith Corporation, Babcock and Wilcox Co., and others. Of course a great number of other concerns and independent investigators were conducting independent developments, so that now a number of concerns produce excellent heavily coated electrodes which have advanced the American welding industry to a foremost place in the art.

A survey of the technical literature indicates that a number of investigators are at work on precise investigations of the nature of the arc, the mechanism of formation of the arc crater, temperature of the arc and the effect of various factors on the stability of the arc, effect of the polarity, the type of electric current, etc.

Since the electric arc is the tool with which the welds are made, one must know its nature and peculiarities in order to use it with a maximum of efficiency.

It is well established that the conduction of the electric current in the arc is an ionic phenomenon and that most of the current is being carried by the electrons. Yet without the continual production of positive ions in the arc stream, the arc phenomena would be impossible. The facility with which the atoms and molecules of gases and vapors, which may happen to be in the space between the weld and the electrode are ionized, will have a very marked effect on the temperature of the arc and its stability and distribution of energy between cathode and anode. And these factors will greatly influence the facility with which nitrogen of the air will combine with the materials present in the arc and therefore determine the quality of the weld.

The ionizing potential of oxygen, nitrogen, iron, titanium, calcium, sodium, and potassium, are respectively 13.5, 10.8, 7.4, 6.5, 5.1 and 4.1 volts. This suggests immediately that if the vapors of alkaline earths or alkali metals are present in the space between the electrodes, striking and maintaining the arc would be much easier than in air. In selecting the flux, one should also consider its effect on the distribution of energy in the arc. As every electrical engineer knows, in an electric arc maintained between carbon electrodes, three-quarters of the energy is liberated at the anode, almost one-quarter at the cathode, and only a very small amount in the arc core.

In case of an arc maintained between a steel plate and a carbon electrode or between a steel plate and a metallic electrode, the distribution of energy is entirely different. In the latter case the energy liberated at the cathode is about equal to that of the anode. Furthermore, its distribution can be greatly influenced by the fluxes. For instance, such fluxes as $NaFe(SiO_3)_2$, $FeSiO_3$, $CaMg_3(SiO_3)_4$, Al_2O_3 or MgO would increase the amount of energy liberated at the cathode. The first-named flux used on one commercial electrode will create conditions under which 60% of the total energy of the arc will be liberated at the cathode. For this reason the manufacturers of that electrode recommend the use of reversed polarity, otherwise the electrode would melt too fast and the penetration would not be sufficient.

Other fluxes such as CaO, TiO_2, and Na_2O would have the opposite effect, that is, a larger percentage of energy would be liberated at the anode. The temperature of the arc could also be influenced by the proper selection of the fluxes.

Turning now to the question of how, and in what part of the arc nitrogen unites with iron, one must first of all remember that molecular nitrogen does not react with molten iron. In the Bessemer Process, tens of thousands of cubic feet of nitrogen are blown through every ton of molten iron, and yet the increase of nitrogen contained in the produced steel is small.

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To become chemically active, nitrogen must be in the atomic state. Yet to produce atomic nitrogen, it requires three times as much energy as in the case of atomic hydrogen, namely, 274,000 calories per mol as against 98,000 calories per mol of hydrogen. Furthermore the dissociation of nitrogen into the atomic state does not begin until the temperature of 3500° C. is reached, whereas the dissociation of hydrogen is appreciable at 1900° C. This indicates that the contamination of iron with nitrogen can occur only at the arc core, that is, either along the arc core in the arc stream or at the foot of the arc core at the "cathode or the anode spot" in each crater. If the arc core is short, and therefore more easily protected from the contact with nitrogen, then there is hope that the weld will contain a small percentage of nitrogen even if the gas does come in contact with the molten metal in the crater.

It would seem that a further study of such factors as the composition of the fluxes, influence of the polarity, and the type of current used, always followed by the metallographic investigation of the deposited metal, will be very useful and would lead to immediate appreciable results.

Dr. J. W. Miller's Paper

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Introduction

In recent years, the process of electric arc welding has made very remarkable strides and has gained an important foot-hold in various industrial fields. A great deal of attention is now being given to the physical testing of metal deposited by the electric arc and a great deal of research has been, and is still being done, to improve the quality of the deposited weld metal.

One of the most important, and yet, one of the most difficult problems with which the welding engineer is confronted is the control of the nitrogen content in the deposited weld metal. A number of investigators have worked on this subject but no one of them has endeavored to cover the entire subject. For the most part, the work has been concentrated upon the effect of fthe nitrogen in the deposited metal and not upon the actual control of the nitrogen content.

The Occurrence and Appearance of Nitrides in Weld Metal

In weld metal, iron-nitride occurs most frequently as needles, together with colorless, structureless areas, and Braunite. A large number of people, including the author, are of the opinion that these needles which we observe, may, in reality, be cross sections of plates occurring in the metal. The following photomicrograph, Figure 1, taken from a weld deposited by a 0.015 per cent carbon, 0.016 per cent manganese electrode upon which was a slight stabilizing coating, shows the zig-zag manner in which the needles are frequently found. The metal contained 0.112 per cent nitrogen.

Figure 2 shows the structure of weld metal deposited by a bare, 0.015 per cent carbon, 0.016 per cent manganese electrode. This material contained a constituent which appeared similar to pearlite when examined at low magnifications.

Regardless of how high a magnification was used when examining this material, no sign of the "thumbprint" structure, which is so common for pearlite was observed. By analysis, the weld metal contained 0.016 per cent carbon and 0.135 per cent nitrogen. It is quite obvious that the carbon content of the material was so low that one would not expect to find any structure present which could be attributed to carbon. A careful study of the photomicrograph will illustrate however, that all of the structure present is very easily accounted for by the nitrogen content of 0.135 per cent. The large dark areas are commonly called Braunite, and correspond, in the iron-nitrogen system, to pearlite in the iron-carbon system—both being the eutectoid structures.

It is very common to find structureless, colorless areas in weld metal which contains nitrogen. A few such areas may be observed in Figure 1. In some samples, a large number of such a constituent was present with almost no needles. After annealing such samples however, there was a large number of needles present and very few patches of the colorless, structureless constituent. It may be that these structureless areas are due to the rate of cooling of the weld metal. At the welding temperature, and during part of the cooling, the iron-nitrides are dissolved in the austenite and upon the transformation to alpha iron, iron-nitrides are precipitated in the form of needles. Due to the rapidity of cooling, the segregation is incomplete and the result is areas of ferrite which are rich in nitrides of iron. This might be termed a "secondary" ferrite. This would account for the colorless, structureless areas which are present in the high nitrogen weld metal.

A phenomenon similar to this has been noticed in low carbon steels in which the segregation, or complete separation of the iron-carbide has been inhibited (between the Ar_1 and Ar_3) by the cooling rate and a "secondary" ferrite formed. This material is also a colorless, structureless constituent which has definite lines, or boundaries of demarcation.

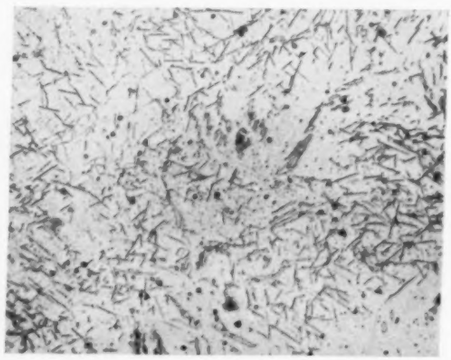


FIG. 1

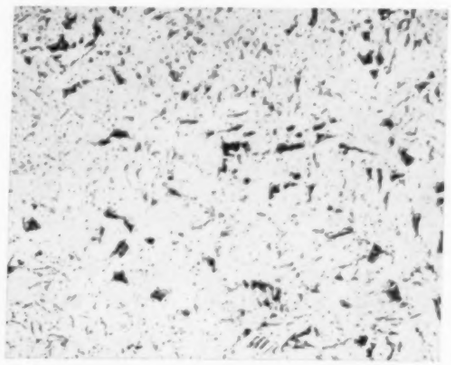


FIG. 2

During the annealing operation, the iron-nitrides are given a sufficient amount of time to segregate in the form of needles and for that reason, we see very few of the colorless areas in annealed samples. It is probable, that if the material were cooled sufficiently slow, there would be none of the colorless, structureless constituent present at room temperature.

It was also noted, that the nitride needles sometimes segregated and that they might be precipitated at both the grain boundaries and within the grain itself. In some instances, widened grain boundaries were evident.

In attempting to eliminate the formation of iron-nitride, various coatings have been devised for protecting the electrode, arc, and crater metal. These coatings have, to a certain extent, been successful but certain types are far more efficacious than others.

X-Ray Diffraction Investigation of Weld Metal

At the outset of the investigation, it was hoped that an X-ray diffraction investigation would give some proof of the composition and structure of the

needles appearing in the weld metal. For this investigation, a Phragmen camera of the Seemann-Bohlin type was chosen. A chromium target was employed.

A weld was made with a 3/16 inch, bare electrode, using 150 amperes and 22 volts. The chemical analysis of the electrode was as follows:

C	0.015
Mn	0.016
P	0.004
S	0.020
Si	0.011

The chemical analysis of the deposited weld metal, made under the conditions stated was:

C	0.016
Mn	0.016
P	0.009
S	0.018
Si	0.008
N	0.127

A sample of this weld metal was filed off with an extremely fine file and the filings used were those which passed through a 200 mesh screen. The filings were, of course, in a cold worked state and for that reason it was necessary to anneal them to relieve this strained condition. To prevent oxidation of the filings during the annealing operation, they were placed in a combustion tube which was evacuated and sealed. This sealed tube was placed in the furnace and heated to 1150° Fahrenheit for one hour and allowed to cool to room temperature with the furnace.

A diffraction pattern of this sample showed, not only the lines due to alpha iron, but also some strange lines. Upon measuring the film and comparing the $\sin^2\theta$ values of the strange lines with those values obtained by Hägg in his work on the iron-nitrogen system, ([49]) it was found that two of the strange lines were identical with those values obtained by Hägg for the gamma prime phase of the iron-nitrogen system. The weak lines in the case of the weld metal corresponding to the very strong lines of the gamma prime phase of the iron-nitrogen system.

In order to more definitely establish as to whether or not these lines were due to the gamma prime phase of the iron-nitrogen system being present, the heat treatment of the previous sample was repeated except that in this case, the evacuated combustion tube containing the sample was removed from the furnace, after it had been at the temperature of 1150° Fahrenheit for fifteen minutes, and broken in a carbon dioxide ice—carbon tetra chloride mixture which gave a quenching temperature of –19.5° Centigrade. This was done in order to retain the iron-nitride in the form of solid solution in the alpha iron.

The diffraction pattern of this sample showed some of the strange lines, the only difference being in the lines which were due to the gamma prime phase of the iron-nitrogen system. The stronger of the two gamma prime lines of the annealed sample showed very weakly in the quenched sample, the weaker line not showing at all. This would indicate that either the sample was not quenched with sufficient rapidity to retain the iron-nitride in the form of solid solution, or that there had been some precipitation of the iron-nitride during the three hour exposure of the X-ray camera. The latter explanation seems, to the author, to be the more logical. Hensel and Larsen ([38]) reported considerable aging to have taken place in a very few hours at room temperature.

Upon a microscopic examination of annealed and quenched samples of the same weld, it was found that the needles were present in large quantities in an annealed sample but were absent in a quenched sample. This, considered with the X-ray diffraction results, proves that the needles in weld metal are probably the gamma prime phase of the iron-nitrogen system and correspond to the compound Fe_4N.

Eight strange lines, other than those belonging to the gamma prime phase of the iron-nitrogen system were present in the diffraction pattern which were not accounted for. These eight lines were present in both the annealed and quenched samples with equal intensity. Upon microscopic examination of unetched samples in both the annealed and quenched conditions, it was found that considerable impurities were present in the metal. It was the opinion of the author that these lines were probably due to oxide impurities and for that reason, samples of ferrous-, ferric- and ferrous-ferric oxides were investigated and diffraction patterns obtained. None of the lines of the ferrous or ferric oxides corresponded to the strange lines but the ferrous-ferric oxide pattern corresponded to four of the lines. This shows that these four lines were due to the presence of the magnetic iron oxide in the weld metal.

The four strange lines which were unaccounted for, were probably due to slag material such as complex silicates or complex oxides. They were however, present in the same intensity in the pattern, regardless of the heat treatment which the sample received.

Due to the fact that the needles were the only constituent to disappear upon heat treatment by quenching, and due to the fact that the two lines of the gamma prime phase were the only lines which disappeared in the diffraction pattern upon quenching, it would tend to prove quite conclusively that the needles were probably due to the gamma prime phase of the iron-nitrogen system which corresponds to the compound Fe_4N.

It is the author's opinion that it was the precipitation of the compound Fe_4N which caused most of the age hardening phenomenon observed by Hensel and Larsen ([38]) in arc weld metal.

Blow Holes In Weld Metal

Considerable interest has recently been shown in endeavoring to determine the nature of the gas, or gases, which cause blow holes in weld metal. The gases present which might cause the blow holes are:

1. Oxygen
2. Carbon-monoxide
3. Carbon-dioxide
4. Hydrogen
5. Nitrogen
6. Hydrocarbons

There is the possibility that hydrogen is dissolved in the weld metal and reacts with the carbon present to form some hydrocarbon whose solubility decreases with a decrease in temperature and is thus liberated and forms blow holes.

It is well known that the surfaces of the blow holes, in a freshly fractured weld are shiny and free from oxidation. For that reason, it is quite evident that the gases present are not oxidizing. This shows that the blow holes are not caused by oxygen or carbon-dioxide because both of these gases are oxidizing at the tempearture at which the blow holes form in the weld.

It has been the author's experience that it is almost impossible to remove nitrogen from steel when present in small quantities, without the use of vacuum at extremely high temperatures. During the cooling of the molten metal at the high temperatures, there is no vacuum present and the tendency of the metal is to absorb nitrogen rather than to liberate it. Also, the gases causing the blow holes are liberated with a decrease in the temperature of the metal. There is evidence, that at the high temperatures encountered during the welding operation, the solubility of nitrogen in iron increases with a decrease of temperature. Furthermore, the author has seen welds made in a nitrogen shield which were free from porosity. For these reasons, it is very highly improbable that nitrogen causes blow holes in the weld metal.

The above eliminates the probability of carbon-dioxide, oxygen and nitrogen as causing blow holes and leaves hydrogen, carbon-monoxide and possibly hydrocarbons as probable gases for causing blow holes. The author has not experienced a weld entirely free from porosity when a hydrogen shield was employed. Welds made in an atmosphere which was composed largely of carbon-monoxide were extremely porous—the same was true when methane was used as a shielding agent. This would indicate that the blow holes in arc weld metal are caused, for the most part, by carbon-monoxide and hydrogen and any hydrocarbon gas which might be present.

The Effect of the Nitrogen Content in the Welding Atmosphere Upon the Nitrogen Content of the Deposited Metal

From mathematical considerations developed by Steinmetz, ([17]) it is quite evident that a change in the per cent nitrogen in the arc atmosphere would cause a considerable change in the per cent nitrogen fixed and "picked up" during the welding operation. It was therefore necessary to determine the effect of a variation in the nitrogen content of the welding atmosphere upon the per cent nitrogen in the deposited metal.

Welds were made in varying atmospheres using 5/32 inch, 0.13 to 0.18 per cent carbon, bare electrodes. The results thus obtained were as follows:

Sample No.	Atmosphere	% N in Deposited Metal
G1	Pure H_2	0.0255
G2	75% H_2—25% N_2	0.0500
G3	25% H_2—75% N_2	0.0717
A27	Air	0.107
G4	Pure N_2	0.143

The shields in which these welds were made were merely pipe type shields held parallel to the side of the electrode. For this reason, some nitrogen and oxygen were present in the atmosphere when pure hydrogen was used and some oxygen was present when pure nitrogen was used. The reason for adopting this type of shield was that the box type is not commercially applicable, and these results are

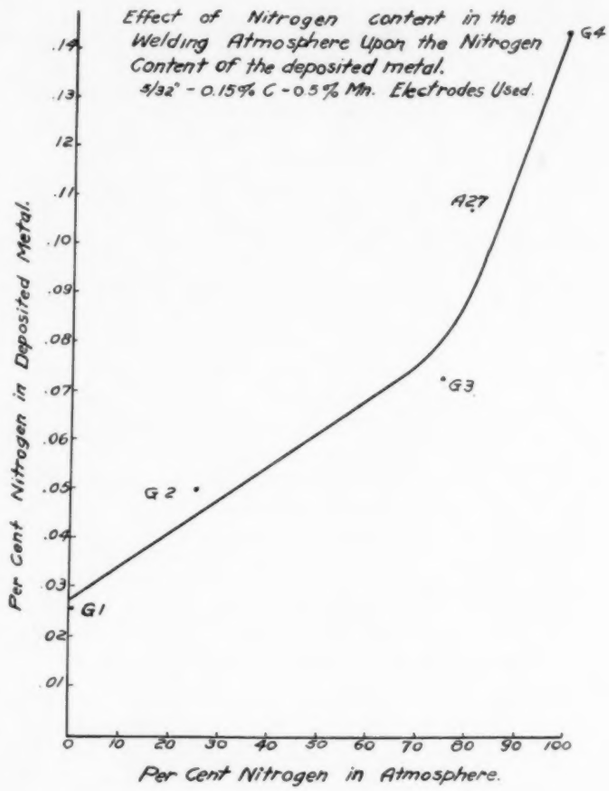


FIG. 3

therefore comparable to those which are obtained when the commercial type of shield is employed.

Figure 3 shows a graphical illustration of the results and illustrates very clearly that the higher the per cent of nitrogen in the welding atmosphere, the higher will be the per cent of nitrogen in the deposited metal.

The Effect of Carbon Content of the Electrode Upon the Nitrogen Content of the Deposited Weld Metal

A series of welds were made keeping all of the welding conditions as nearly constant as possible and varying only the carbon content of the welding electrode.

In this series, all of the electrodes employed were bare, 5/32 inch, hard drawn wire and all of the welds were made with 150 amperes and 20 volts. The carbon content of the electrodes were 0.015, 0.15, 0.37, 0.70, and 1.0 per cent. The results of these tests are shown in Figure 4 and illustrate the fact that as the carbon content of the welding electrode increases, the nitrogen content of the deposited metal decreases.

It is the author's opinion that this phenomenon is partially due to the shielding action of the carbon. As will be seen in a subsequent part of this investigation, a large percentage of the carbon is burned out during the welding operation. It is therefore very probable that the carbon-monoxide or carbon-

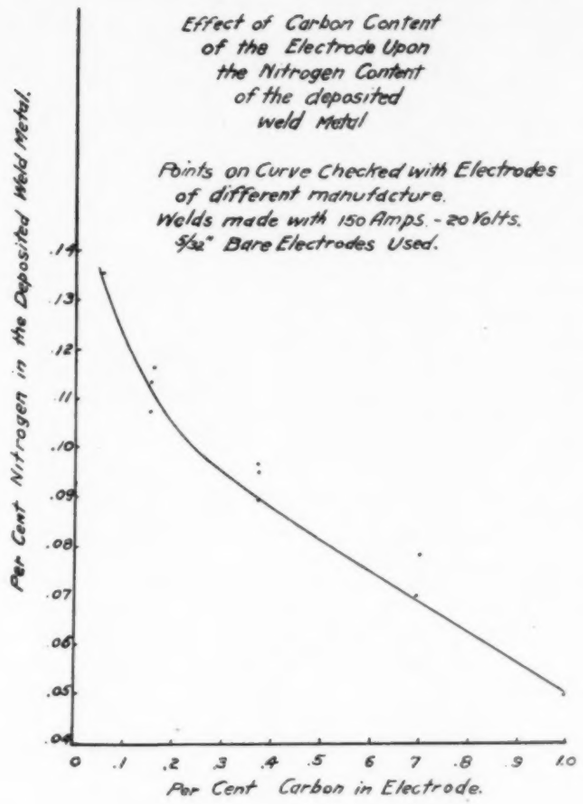

Effect of Carbon Content of the Electrode Upon the Nitrogen Content of the deposited weld Metal
Points on Curve Checked with Electrodes of different manufacture.
Welds made with 150 Amps. - 20 Volts.
5/32" Bare Electrodes Used.
Per Cent Nitrogen in the Deposited Weld Metal.
.14
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1.0
Per Cent Carbon in Electrode.

FIG. 4

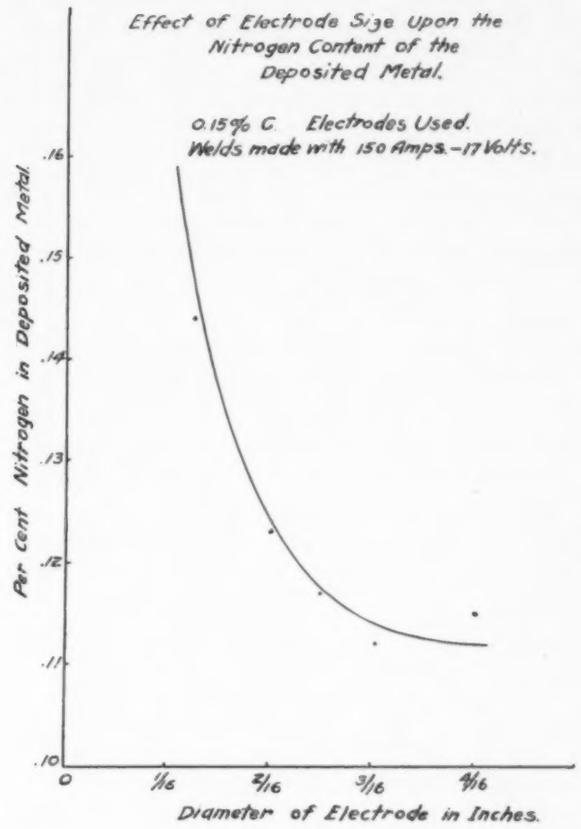


FIG. 5

dioxide formed, act as a shield and decrease the opportunity for nitrogen absorption. It follows that an increase in the carbon content of the electrode would cause a greater shielding effect.

The Effect of Electrode Size Upon the Nitrogen Content of the Deposited Weld Metal

A series of welds were made, using electrodes of the same analysis and 150 amperes and 17 volts, but varying the size of the electrode. The only intentional variable in this series of welds was the size of the electrodes. It is realized of course, that the current density varied with the different sizes of electrodes.

The analysis of the electrodes, regardless of diameter, was:

C	.13 to .18
Mn	.040 to .060
Si	.06 Max
S	.04 "
P	.04 "

The results of these tests are shown graphically in Figure 5.

The author was aware of the fact that 150 amperes and 17 volts were not the correct amperage and voltage, as regards practical application, for some of the electrodes used in this series. This does serve however, to illustrate very clearly that an increase in the electrode diameter causes a decrease in the nitrogen content of the deposited weld metal. As will be seen in a subsequent part of the investigation, a decreased amperage in the case of the 3/32 inch electrode would have caused an increase in the nitrogen content of the deposited weld metal, and an increased amperage for the 1/4 inch electrode would have caused a decrease in the nitrogen content of the deposited metal. This would indicate that, had the welds of this series been made under commercial conditions as regards amperage and voltage, the slope of the curve in Figure 5 would have been much more steep.

As will be shown later, the phenomenon of the absorption of nitrogen occurs on the tip of the welding electrode when straight polarity is used. It follows therefore, that the larger the diameter of the electrode, the less surface, per unit weight of metal, will be exposed to the atmosphere of the arc for nitrogen absorption and the smaller the diameter of the electrode, the greater will be the surface exposed, per unit weight of metal, for nitrogen absorption. As the nitrogen absorption is a phenomenon of reaction with the surface metal and subsequent penetration, one would expect that an increase in the diameter of the electrode used would cause a decrease in the nitrogen content of the deposited weld metal. As seen in Figure 5, this hypothesis has been experimentally verified.

The Effect of Amperage and Voltage Upon the Nitrogen Content of the Deposited Weld Metal

In order to determine the effect of the amperage and voltage upon the nitrogen content of the de-

posited weld metal, a series of welds were made using a constant low voltage with high, medium and low amperage, medium voltage with high, medium and low amperage, and high voltage using high, medium and low amperage. The general results of these tests indicated that an increase in the amperage caused a decrease in the nitrogen content of the deposited metal and that an increase in the voltage caused an increase in the nitrogen content of the deposited weld metal. The differences in the nitrogen contents were, however, quite small as regards their magnitude.

It should perhaps be stated at this time that the author was unable to detect any difference in the nitrogen content of the deposited metal when hard drawn and annealed electrodes were used, providing that other conditions remained constant.

The Influence of Reversed and Straight Polarity Upon the Nitrogen Content of the Deposited Weld Metal

The question has frequently been asked as to where the nitrogen is absorbed in the weld metal and where the carbon is eliminated during the welding operation. When heavy coated electrodes are used, it is nearly always required that reversed polarity be used and the effect is that the nitrogen content of the deposited metal is generally diminished.

During this investigation, a large number of samples of electrode tips were obtained for chemical analysis. These samples were made by striking the arc, letting the electrode cool and carefully removing the extreme tip of the electrode. This extreme tip of the electrode corresponding to the metal which was adhering to the electrode tip in the molten state during welding and those samples will be referred to as "electrode tips." Another set of samples was made by allowing the tip of the electrode to become molten in sufficient quantities so that a drop was about to fall upon the plate metal. At this time, the electrode was given a quick "flip" and the adhering drop, which should closely correspond to arc metal, was thrown onto the plate, outside of the crater region, so that no actual fusion occurred. These drops were collected for analysis and will be referred to as "buttons." The third sample taken for analysis was from metal deposited in the usual manner. The above was then repeated using reversed polarity.

In the both the reversed and straight polarity, 5/32 inch, bare, 0.37 per cent carbon, 1.0 per cent manganese, hard drawn electrodes were used and the welds were made with 125 amperes and 20 volts.

The results of the rod tips, buttons and weld metal made with straight polarity were as follows:

Material	% C	% N
Original Electrode	0.37	0.007
Rod tips	0.105	0.092
Buttons	0.115	0.110
Weld metal	0.125	0.090

As may be seen in the table of results when straight polarity is used, the nitrogen is absorbed at the tip of the electrode and the carbon is eliminated at the same place.

It should be stated, that the size and shape of the samples made the carbon analysis exceedingly difficult in the case of the buttons, and it is highly probable that a small error may be present in the carbon analysis of the buttons. It was very easy however, to obtain exceedingly accurate results in the rod tip and weld metal. There was very definite proof that the carbon was burned out at the tip of the electrode. In the case of the weld metal which had been deposited on 0.20 per cent carbon plate, there was undoubtedly some diffusion of carbon from the plate metal into the weld metal which would account for the increase of carbon from the rod tip to the weld metal.

It will be noticed in the case of the straight polarity that there is a decrease in the nitrogen content of the weld metal upon passing through the arc and into the crater. With straight polarity, the plate metal is hotter than the rod tip and as previously shown, there is a decrease in the solubility of nitrogen with an increase in the temperature. It is therefore reasonable to assume that the decrease in the nitrogen content of the metal when passing from the rod tip to the crater was due to the increase in temperature, which means a decrease in the solubility of nitrogen in iron.

The results of the rod tips, buttons, and weld metal made with reversed polarity were:

Material	% C	% N
Original Electrode	0.37	0.007
Rod tips	0.105	0.053
Buttons	0.115	0.067
Weld metal	0.06	0.098

From the results obtained when reversed polarity was used, one sees that there was a marked increase in the nitrogen content of the metal passing from the rod tip to the crater. Also, that there was a marked decrease in the carbon content of the metal passing from the rod tip to the crater. This again shows that the nitrogen is absorbed under conditions which cause carbon to be eliminated. This may be due to the nitrogen and oxygen forming nitric-oxide (NO) in the arc which reacts with the iron to form iron-nitride and liberates atomic oxygen which reacts with the carbon. This seems to the author as being a logical explanation for the fact that the nitrogen is absorbed under conditions which burn out the carbon. If some of the atomic oxygen reacted with the iron, it would also explain the fact that weld metal containing a high nitrogen content usually contains a high oxygen content.

It will be noted in a subsequent part of the investigation that when heavy coated electrodes are employed which retain most of the carbon in the metal, there is very little nitrogen absorbed and the metal is quite low in oxygen. This is additional proof that conditions which lead to the absorption of nitrogen are, at the same time, conditions for the liberation of carbon and contamination by oxygen which is further verification for the theory that the nitrogen fixation, when welding in air, is caused by the nitrogen reacting with oxygen. It is known however, that the electric arc is capable of breaking molecular nitrogen down into active atomic nitrogen which will react directly with the iron to form iron-nitrides.

In the case of reversed polarity, the rod tip is hotter than the plate metal and one would expect that the solubility of the iron for nitrogen would tend to increase when the metal passes from the rod tip to the crater. This, as seen in the table, was experimentally verified. Again showing that an increase in

the temperature of the molten metal causes a decrease in the solubility of nitrogen in iron.

Physical Tests Upon Metallic Arc Weld Metal

At the outset of the investigation, there was some difference of opinion as to the proper method of making, or depositing, weld metal so that physical specimens, free from plate metal, might be obtained. It was first suggested that pads be laid on low carbon plate metal and physical tests specimens be machined from them as was done by Rawdon, Groesbeck and Jordan. [23 and 24] The author was advised however, that weld metal deposited in the form of pads was not analogous to weld metal deposited in a 90° V type of weld which is the most common in the welding industry. For this reason, it was decided to obtain physical samples in the manner illustrated in Figure 6. As seen in the diagram, all of the reduced sections of both the standard 0.505 inch tensile samples are the Charpy samples were composed entirely of weld metal so that plate metal effects were eliminated. When preparing the samples for machining, the author macro-etched each sample and center-punched it so that there would be no possibility of any plate metal being in the machined specimen.

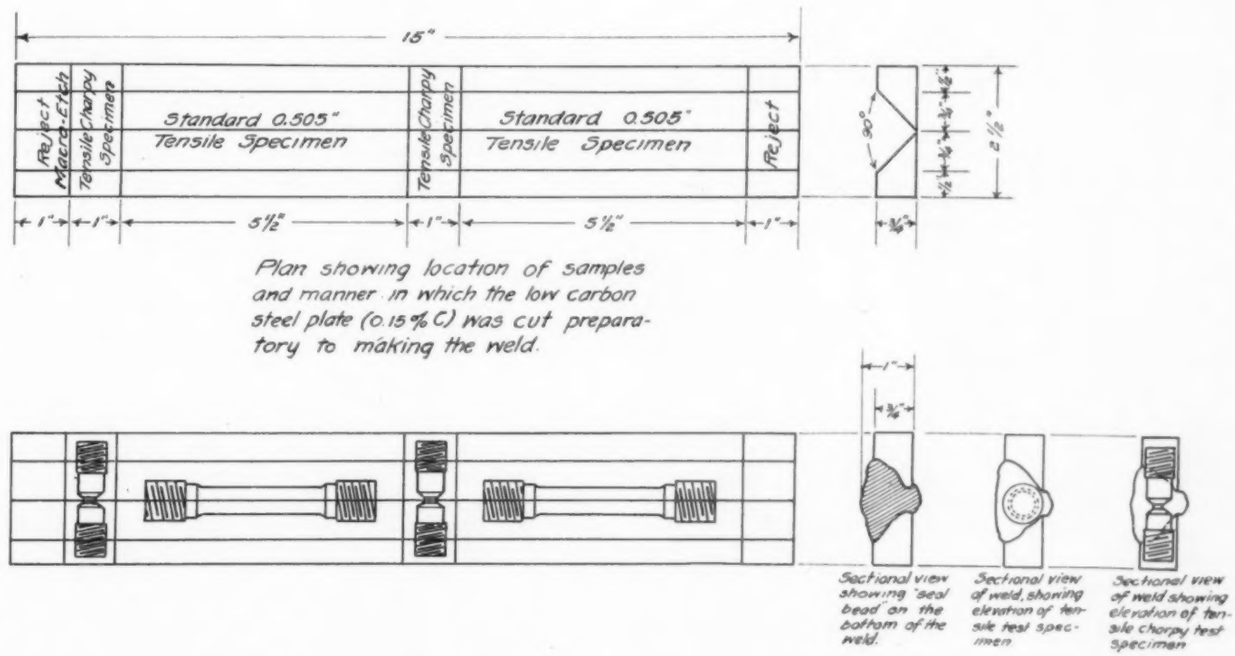
An expert experimental welder was obtained to make the physical test samples. This welder was quite familiar with practically every type of electrode available and made all of the welds for the physical test samples. By having one man make all of the welds, the chances of personal errors entering into the work were minimized. The only type of welds which the operator was not familar with were those in which gaseous shields were used. This will be discussed in more detail later.

A seal bead, such as is illustrated in Figure 6, was made on each weld. The object of this seal bead was to assist in refining the structure of the weld metal and to fill any blow holes or cavities which might have been present at the bottom of the V

Hensel and Larsen [38] found that the aging phenomenon was at a maximum in about ten days. In this investigation, the minimum time between making and testing the weld was twenty-one days. This precaution was taken in order that the aging phenomenon might reach a maximum before the physical tests were made. By allowing this amount of time for aging, the author was quite confident that any difference in the physical test results could not be attributed to a difference in the aging.

After the physical test samples had been machined, each set (a set consisting of two tensile and two Charpy samples made from the same weld) were radiographed for porosity and inclusions. The radiographic results, as read from the negatives are given in tabular form (Figure 7). These results were also checked by macro-examination of cross sections of the welds.

The complete information, as to the diameter and analysis of the electrode, the welding conditions, coating on the electrode, porosity, fracture appearance, physical properties, and nitrogen content of the



METHOD OF OBTAINING SPECIMENS FOR PHYSICAL TESTS

As illustrated in the plan and elevation views, the reduced sections of both the tensile and charpy test specimens are composed entirely of weld metal which eliminates plate metal effects when testing the specimens.

FIG. 6

deposited weld metal of each sample used for obtaining physical tests data is given in Figure 7.

The author endeavored to plot the information in the results but was unable to do so because of the fact that there was an insufficient number of samples used. That is to say, that the variation of the amperage and voltage for any given size and composition of electrode was not sufficient to warrant graphical representation. Another attempt was made to plot the physical properties against the nitrogen content for electrodes of a given carbon content, disregarding the amperage, voltage and coating used. In this case, there was obtained, merely a group of points at the high nitrogen contents which resulted from bare electrodes and another group of points at the low nitrogen contents which resulted when heavy coated electrodes were used. The result of this attempt was merely a straight line drawn from one group of points at high nitrogen contents to another group of points at low nitrogen contents. The results were indicative but of such a nature that the author did not feel justified in including them in graphical form. In place of the graphs, a general discussion was decided upon.

From Figure 7, it will be seen that in those welds made with 0.15 per cent carbon, bare electrodes (samples A41 to A52, samples A63, T3 and T5) an increase in the nitrogen content of the weld metal caused an increase in the tensile strength and yield point. The results, as regards the per cent elongation, per cent reduction in area, and Charpy impact values vary with the nitrogen content in such an erratic manner that one would not be justified in making definite statements in regard to the effect upon them, when there is such a small variation in the total nitrogen content. The same holds true with respect to the proportional limit for these samples.

When using 3/16 inch bare electrodes of one particular manufacture, the best physical properties were obtained with 175 amperes and 16 volts (A45). It will be seen that this combination gave the highest nitrogen content for the 3/16 inch, bare electrode series. The ¼ inch electrode of the same manufacture and analysis gave the best physical properties with 225 amperes and 22 volts (A51). Here again, as was the case in the 3/16 inch series, the best physical properties were not obtained with the lowest nitrogen content. It will be noticed however, that the total fluctuation in the nitrogen content of these samples was very small and for that reason, other effects, such as grain size, cooling rate, structural differences, and oxygen content might very easily overcome effects of so small a variation in the nitrogen content.

As would be expected from the earlier part of this investigation, samples A53, A54, A55, and A56 show that with an increase in the carbon content of the electrode, there is a decrease in the nitrogen content of the deposited metal. Also, due to the increasing amounts of carbon in the deposited metal, there is an increase in the proportional limit, yield point, Charpy impact, and tensile strength with a corresponding decrease in the per cent elongation and per cent reduction of area.

In the physical results obtained from samples A56 and A57, which welds were made under identical conditions except that the electrodes used in the case of A57 had a slight lime wash coating, it will be noted that the weld made with the lime washed electrodes (A57) gave a slight increase in the physical properties and caused a decrease in the nitrogen content.

A comparison of samples A55 and A58 again show that there is no appreciable difference in the nitrogen content of the deposited weld metal whether the electrode is annealed or hard drawn. In this instance however, the hard drawn electrode gave a deposit with slightly superior physical properties.

In the case of both sets of samples (A55 and A58, A56 and A57) however, the sample with the lower nitrogen content resulted in the better physical properties.

In the making of the shielded arc samples, G8, G9 and G10, the welder was not experienced with the use of a shield and as may be seen from the nitrogen content of the samples, the shielding was not very effective. The results of previous work done with a hydrogen shield would indicate that sample G9 should have had a nitrogen content of below 0.05 per cent and it was actually 0.121 per cent. This illustrates that the samples were not representative of shielded welds, and for that reason, the author does not consider them as such. Had it not been for the fact that the author wished to eliminate personal error as much as possible, he would have had the shielded welds made by an individual who was experienced in the use of gaseous shields. Had such been done however, any differences in the properties of the shielded and unshielded welds might have been attributed to the difference in the welding skill of the operators and this type of controversy was intentionally avoided.

It will be seen that in the case of the welds made with heavy coated electrodes, where the nitrogen content of the deposited weld metal was below 0.05 per cent, the physical properties of the metals were greatly improved. Between 0.02 and 0.043 per cent nitrogen, obtained when heavy coated electrodes were used, there could be no straight-forward correlation drawn between the nitrogen content of the weld metal and the physical properties. This would indicate that between these very low limits of nitrogen contents (0.02 to 0.043 per cent) other factors, such as the cooling rate, elimination of impurities, grain size, carbon content, manganese content, and etc., may have been more influential than the variation of the nitrogen content.

This series of welds, made for physical tests, shows that in the case of weld metal deposited by the electric arc, conditions which cause a marked increase in the nitrogen content of the deposited metal, cause a decrease in all of the physical properties investigated. Previous investigators, working with steel which contained low percentages of nitrogen, found that an increase in the nitrogen content of the steel caused an increase in the tensile strength. It will be noted that in this investigation of arc weld metal, welds made under conditions which cause a decrease in the nitrogen content have an increased tensile strength. This indicates that there are other very important factors beside the nitrogen content to be considered in the case of arc weld metal. Such factors being, in the author's opinion, heat treatment, grain size, silicon and manganese contents, carbon content, oxygen content, density, and the structure of the weld metal. It should be remembered that

RESULTS OF PHYSICAL TESTS

Sample No.	Welding Conditions								Properties of Deposited Weld Metal								
	Diameter of Electrode	% C in Electrode	% Mn in Electrode	% Si in Electrode	Welding Amperage	Welding Voltage	Polarity ΔΔ	Electrode Coating	Porosity (from Radiographs)	Fracture Appearance (Grain-size) d	Proportional Limit lbs/in.²	Yield Point lbs/in.²	Tensile Strength lbs/in.²	% Elongation in 2 inches	% Reduction in Area	Charpy Impact (Ft.-lbs.)	% Nitrogen in Weld Metal
A41	5/32"	0.15	0.50	0.06 max.	150	14	S	none	none	M	28,900	34,800	51,100	9.5	13.2	2.70	0.126
A42	"	"	"	" "	200	15	"	"	slight	"	27,700	33,400	48,400	9.8	15.0	2.08	0.121
A43	"	"	"	" "	150	22	"	"	none	"	28,900	34,600	52,700	14.5	20.5	1.62	0.128
A44	"	"	"	" "	175	"	"	"	v. very slight	"	22,200	29,900	40,800	7.0	9.4	1.39	0.111
A45	3/16"	"	"	" "	"	16	"	"	very slight	"	26,500	34,700	50,700	11.0	15.0	2.38	0.124
A46	"	"	"	" "	225	18	"	"	"	"	29,200	32,900	49,500	11.5	16.7	2.33	0.117
A47	"	"	"	" "	175	22	"	"	none	"	26,000	31,200	48,900	13.0	13.2	2.09	0.119
A48	"	"	"	" "	225	"	"	"	slight	"	24,900	30,900	43,200	6.5	9.4	"	0.113
A49	1/4"	"	"	" "	"	18	"	"	med-bad	"	26,300	32,500	47,100	9.5	15.0	"	0.088
A50	"	"	"	" "	275	"	"	slight *	slight-med.	"	25,400	32,100	47,800	12.0	16.7	1.85	0.093
A51	"	"	"	" "	225	22	"	"	slight	"	29,900	36,900	50,100	11.0	18.7	1.39	0.111
A52	"	"	"	" "	275	"	"	"	"	"	21,400	29,900	46,400	13.0	16.7	1.62	0.099
A53	5/32"	1.00	0.45	0.02 max.	150	18	"	"	"	F	51,800	61,400	74,200	4.5	5.5	5.59	0.049
A54	"	0.37	1.05	0.10 "	"	"	"	"	bad	M	32,700	37,500	51,700	7.0	9.5	3.55	0.094
A55	"	0.30	0.65	0.05 "	"	"	"	"	very slight	"	31,700	38,400	55,300	13.5	18.7	"	0.095
A56	"	0.09	0.33	" "	"	"	"	none	none	"	27,400	32,400	50,900	"	17.0	1.62	0.129
A57	"	"	"	" "	"	"	"	slight * Δ	"	"	29,700	34,900	52,200	"	20.5	"	0.115
A58	"	0.30	0.65	" "	"	"	"	" Δ	"	"	32,400	37,800	52,200	10.5	16.7	3.30	0.098
A59	"	0.15	0.50	0.06 max.	"	23	R	heavy	"	V.F.S.-C.C.	47,400	48,700	66,400	33.0	65.5	39.46	0.025
A60	3/16"	"	"	" "	225	30	"	"	"	V.F.S.	46,600	51,600	69,500	23.5	36.0	21.49 ‡	0.043
A61	"	"	"	" "	190	42	"	"	v. very slight	F.S.	42,100	42,600	53,700	22.5	40.8	5.12	0.022
A62	"	"	"	" "	115	32	"	"	very slight	F.S.-C.C.	43,400	47,800	60,700	38.0	59.2	21.36 ‡	0.033
A63	1/8"	0.015	0.016	0.011	125	16	S	none	none	M	25,000	31,000	49,900	9.5	11.7	1.61	0.135
A64	3/16"	"	"	"	175	18	"	"	v.very slight	"	26,400	31,400	47,700	10.5	13.0	0.93	0.125
A65	"	0.15	0.50	0.06 max.	200	26	R	heavy	slight	V.F.S.	41,600	44,200	66,800	24.0	42.3	41.70	0.027
G8	1/8"	0.015	0.016	0.011	125	16	S	none a	"	M.	27,200	32,400	50,200	8.0	8.7	1.16	0.136
G9	"	"	"	"	"	"	"	" b	"	"	25,700	31,900	47,900	"	7.5	"	0.121
G10	"	"	"	"	"	"	"	" c	"	"	26,000	32,700	43,100	5.0	9.5	0.93	0.136
T1	5/32"	0.15	0.50	0.06 max.	160	30	R	heavy	"	M.F.	38,700	43,200	54,800	20.0	34.0	14.55	0.029
T2	3/16"	0.015	0.016	0.011	180	20	"	none	"	M	21,400	27,300	43,500	7.0	13.0	1.16	0.110
T3	5/32"	0.15	0.50	0.06 max.	150	16	S	"	"	"	27,400	36,400	54,100	15.0	18.7	2.09	0.115
T4	"	0.70	0.76	0.127	120	32	R	" **	none	"	33,400	46,800	63,700	4.5	9.4	3.80	0.078
T5	"	0.15	0.50	0.06 max.	150	18	S	"	"	"	29,700	33,100	48,800	9.0	15.0	3.05	0.127

NOTE:

* Slight lime wash for stabalizing the arc.

** Polished Electrode

Δ Annealed Electrode

ΔΔ S = Straight R = Reversed

a, b, c. a = Nitrogen shield b = hydrogen shield C = 75% hydrogen-25% nitrogen shield.

d. M = medium V.F.S. = very fine-silky C.C. = cup & cone F.S. = fine & silky

‡ One low value & one high value.

FIG. 7

conditions which lead to a low nitrogen content also lead to a low oxygen content and inhibit the burning out of carbon.

It is therefore the opinion of the author that the properties of weld metal deposited by the metallic arc cannot be accounted for by any one element, or constituent, or by any simple theory, but that the properties are probably due to combinations of elements and constituents, and they could only be explained by complex theories.

It is evident that nitrogen does play a very important part in causing detrimental effects in metallic arc weld metal.

Conclusions

1. The absorption of nitrogen may be diminished by,
   - A. Increasing the carbon content of the electrode.
   - B. Increasing the amperage.
   - C. Decreasing the arc length (voltage).
   - D. Increasing the diameter of the electrode.
   - E. Maintaining a reducing atmosphere.
   - F. Using heavy coated electrodes.

2. Nitrides may precipitate at the grain boundaries or within the grain itself. Nitrogen may also cause widened grain boundaries.

3. The needles present in arc weld metal are probably the gamma prime phase of the iron-nitrogen system and correspond to the compound Fe_4N.

4. The colorless, structureless areas found in arc weld metal are probably ferrite areas which are rich in iron-nitride that has not had sufficient time to segregate in the form of needles.

5. The main oxide present in arc weld metal is magnetite.

6. It is the opinion of the author that carbon-monoxide and hydrogen are largely responsible for the blow holes occurring in weld metal with perhaps the assistance of hydrocarbons.

7. No difference in the nitrogen content of the deposited metal is encountered between the use of annealed and hard drawn electrodes.

8. Conditions which lead to the absorption of nitrogen are conditions which lead to the burning out of carbon and contamination by oxygen.

9. When straight polarity is used, the nitrogen is absorbed at the tip of the welding rod and when reversed polarity is used, some nitrogen is absorbed at the tip of the welding rod, some is absorbed when passing through the arc, and more is absorbed in the crater metal. The carbon is eliminated under the conditions and at the time that nitrogen is absorbed.

10. The nitrogen is, in an air atmosphere, probably fixed as nitric oxide (NO) in the cooler part of the arc and this is probably split up into active atomic nitrogen and oxygen, both of which may react with the metal.

11. The solubility of nitrogen in weld metal decreases with an increase of temperature at the elevated temperatures of welding.

12. Conditions under which nitrogen is absorbed in the weld metal are conditions which lead to a decrease in the values of the physical properties of the weld metal.

13. Nitrogen alone will not account for all of the inferior properties found in some metallic arc weld metal. It is the author's opinion that other factors such as heat treatment, grain size, microstructure, carbon content, oxygen content, manganese content and etc., play an exceedingly important part in controlling the physical properties.

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DISCUSSION OF DR. J. W. MILLER'S PAPER ON NITROGEN IN METALLIC ARC WELD METAL

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Dr. Miller's paper is a valuable contribution to knowledge regarding the influence of nitrogen in the arc welding of low carbon steel. He emphasizes the uncertainties necessarily involved in interpreting the results owing to the impossibility in most cases (when making a comparative test) of confining the difference in the conditions of the test to only one factor. But in spite of this difficulty, Dr. Miller's results are instructive.

The most simple application of the arc process is to the welding together of mild steel parts. In such work, admirable results are obtained under widely

varying conditions and methods. It would appear probable that the influence of nitrogen would become much more apparent and much more might be learned concerning the nature of the fundamental phenomena if, for the mild steel plate metal employed in Dr. Miller's tests, some less readily welded material were substituted. The variations with varying conditions of welding would then be greater and the reasons would probably be more clearly revealed.

Thus, in another series of tests, the plate material employed could with advantage consist of some alloy of the stainless steel kind or possibly some non-ferrous alloy.

Indeed, quite aside from learning about the influence of nitrogen (which is quite properly the only subject the discussion of which is here appropriate) I should like to be permitted to emphasize the growing importance of making progress in the development of processes suitable for successfully arc welding various high grade alloys. It is going to be found vastly more difficult to learn to make such welds by the arc process which will be comparable in quality and speed of welding to those now made on an enormous scale when the material to be joined is mild steel.

Safe Maintenance Work On Industrial Electrical Equipment

(Continued from page 449)

such workmen until the job has been accomplished or completed. This person should be thoroughly competent to administer the prone pressure method of resuscitation.

10. The Electrical Department will designate by the usual warning sign all approaches to roofs, poles or towers where such hazards exist. Workmen should, however, bear in mind that no wire should be touched or handled under any circumstances without first determining through the Electrical Department that it is safe to do so.

11. The Electrical Department will make no new high tension installation or changes to old installations, effecting the location of same, without first consulting the Superintendent of the department involved.

12. All switches on equipment behind repairs should be in "OFF" position so that when power is again restored, no damage to equipment may occur and no accident may be caused through any unexpected movement of such equipment.

13. No plug type high voltage cutout fuses (commonly called primary cutouts) shall be changed while power is on. This also to apply to high voltage cartridge type fuses wherever possible. In cases where this cannot be done, the following rule shall be observed. "No primary cutout of the plug type is to be handled without the use of a plug puller. A switch hook is to be used in handling the expulsion types. The plug puller and switch hooks to be fitted with treated wood handles not less than 3½ feet in length for voltage up to 7,500 volts; the length of the handle for the higher voltages to be in accordance with the voltage of the circuit. No high voltage cartrige type fuse will be handled without the use of wooden or fiber fuse sticks or tongs suitable for the fuse and voltage of the circuit."

14. Employees should bear in mind that accidental contacts with any high voltage circuits are very dangerous, and they should not touch any conductors carrying High Voltage. There are many special conditions which make electrical work dangerous. It is impossible to explain in detail all such possible cases; therefore, every plant should develop safety rules governing local hazards in connection with High Voltages.

In dealing with electrical maintenance work there is another item which should be insisted upon in all installations, and that is the marking and tagging of switches, circuits and other equipment. The proper identification of switches and equipment when clearing lines is imperative. The scheme of identification is a matter of personal choice, whether it be by numbers, letters, or some other symbol, but in any case a system should be followed that will be consistent throughout the plant involved. Identification markings should be distinct and plainly visible so there is absolutely no possibility of error in selecting the piece of equipment that should be operated. We have seen some very serious accidents as the result of opening disconnecting switches under load, due to mistaken identity of switches. Some plants employ a map showing the location of all poles and towers and give each a separate number. This map is framed and placed in different locations, especially in the substations. In connection with the map there may be a loose leaf book or card system, with a separate leaf or card for each pole or tower and its number, showing the location of all service lines, etc. By referring to the pole number on the leaf or card, a man can tell just what lines he may come in contact with, if there is work to be performed on same. Diagrams of electrical systems showing main circuits and switches with their identification markings should be posted in conspicuous places, such as substations, power houses, and any other parts of the plant where they may be required for reference.

In general, all electrical repairs, even the most trivial, should be done only by experienced electrical maintenance men. Anyone not entirely familiar with electrical apparatus and its hazards puts himself in danger when attempting to repair it. Safe practice prohibits any but capable and authorized persons from making repairs (regardless of the nature) to electrical equipment, even to replacing fuses; for a blown fuse is usually an indication that something is wrong and that the trouble, as well as the fuse, should be corrected. So often a repair that may seem trivial presents a real hazard.

All high voltage lines (generally defined as 440 volts or higher) should be dead before any work is done on them. Even on low voltage lines, wherever practical, all work should be done with the power off. However, those of us who have had experience with electrical maintenance in industrial plants know that it is not always possible to make all lines dead, especially on the lower voltages. Yet it is possible to work on these lines with some degree of safety.

This work, however, should be done only in emergency cases and by very competent and trained men under the closest supervision and careful instructions as to what is involved. Rubber blankets, fiber shields, rubber gloves, etc., should be employed in such work.

Much has been done, written and said regarding preventatives for accidents in all lines of industrial work. Tremendous strides have been made; untold dollars have been spent for safeguards; safety campaigns have been initiated and carried out; yet too many accidents still occur. As we all know, safety is now progressing by education of the men themselves, by teaching them to work safely. After we have supplied the best kind of equipment, provided all the safeguards in the way of tools, rules, etc., the safety consciousness of the workmen involved is the most important item. This can only be obtained by the persistent drive on safety from the management down through the superintendents and foremen to the lowest man in the organization.

Briefly summing up the foregoing, we find the following cardinal points to be factors entering into accident prevention work in connection with safe maintenance work on industrial electrical equipment:

1. Good and approved equipment.
2. Proper installation.
3. Correct safeguarding.
4. Good repair tools and equipment.
5. High type of men.
6. Proper safety education.

ITEMS OF INTEREST

PERSONNEL CHANGES

▲

At a meeting of the Board of Directors of The Timken Roller Bearing Company on October 30, L. M. Klinedinst was elected to the Board and also promoted to the office of Vice President in Charge of Sales to fill the vacancy created by the recent resignation of Judd W. Spray. Mr. Spray plans to spend the winter in Florida and rest indefinitely before announcing his future plans.

Mr. Klinedinst has been associated with The Timken Company for twenty-nine years, having started his business career there as a young man immediately upon completing school.

Thirteen years ago, when the company started expanding into the industrial field, he was made General Manager of the Industrial Division. He has been Vice President in Charge of all Industrial Sales since 1930.

T. V. Buckwalter who has been Vice President of The Timken Roller Bearing Company for several years, was elected Vice President and Director of The Timken Steel & Tube Company.

The Timken Roller Bearing Company announces the appointment of Whitley B. Moore to the position of General Manager of the Industrial Division. Mr. Moore, who is a mechanical engineer, was graduated from the University of Michigan in 1918, going immediately into service in the U. S. Navy. At the close of the war, he joined the engineering staff of The Timken Roller Bearing Company.

In 1921, Mr. Moore was transferred to the Pacific Coast in charge of sales in that territory. In 1924 he was brought back to Canton to take the position of Assistant General Sales Manager of the Industrial Division. In 1930 he was made Sales Manager, and has remained with the Company in that capacity up to the time of his present advancement.

John L. Young, until recently District General Manager in charge of the Pittsburgh office of The Timken Roller Bearing Company has been advanced to the position of Assistant General Manager of the Industrial Division and will move to Canton, Ohio to take over his new duties in the near future. Mr. Young joined the Timken organization in 1921.

Harry D. Robb, who has been with The Timken Roller Bearing Company since 1925 on sales engineering work in various territories, has been advanced to the position of District Manager in charge of the Pittsburgh office, succeeding John L. Young, who has been transferred to the Canton office.

Harry H. Wood, who has been on The Timken Roller Bearing Company engineering and sales staff in Canton since 1929, specializing in the application of Timken Bearings in steel mills, has been transferred to Pittsburgh, and appointed Manager of the Rolling Mill Division.

▲

Following a recent meeting of the Board of Directors of the Westinghouse Electric & Manufacturing Company, President F. A. Merrick announced the election of three vice-presidents, Roscoe Seybold, formerly comptroller; William G. Marshall, formerly assistant to vice-president; and Ralph Kelly, formerly director of budgets. They will make their headquarters in East Pittsburgh.

▲

Charles H. Reinert, former superintendent of the Brooklyn plant of Steel and Tubes, Inc., has recently accepted the position of Assistant Superintendent of the Electric Weld Tube Mill of the parent corporation, Republic Steel Corporation at Youngstown, Ohio.

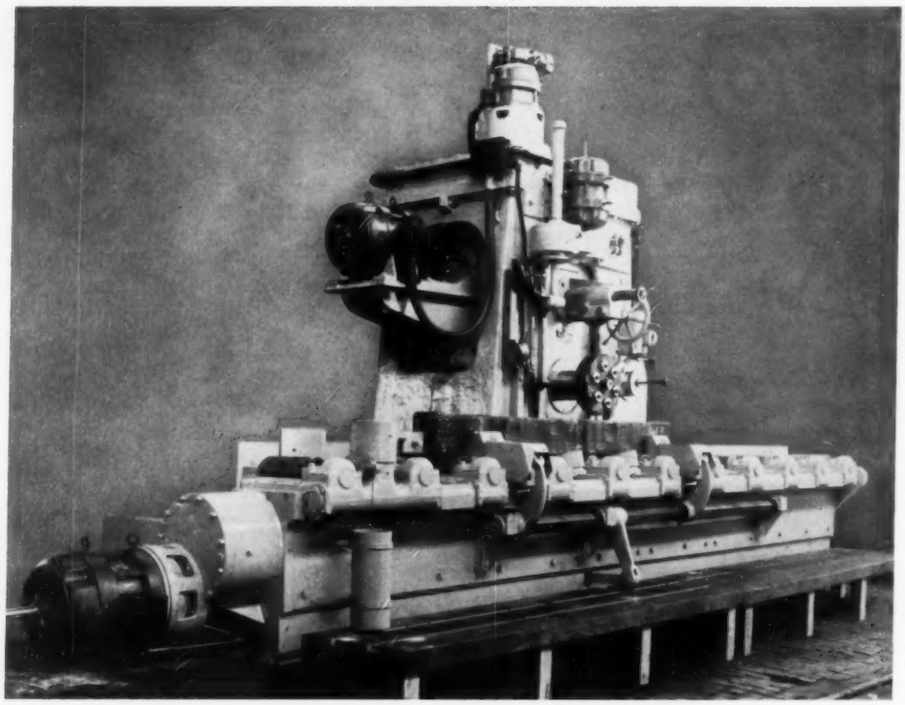
M. B. Steele, until recently a sales engineer working out of the Cleveland Office of Steel and Tubes, Inc., is now assisting E. T. Glass, Sales Manager of the New England Division, and has his headquarters located in Boston. Mr. Steele is a graduate of Worcester Polytechnic Institute.

▲

The American Rolling Mill Company is announcing the opening of a new sales office in Buffalo, New York, located at Seventeen Court Street Building.

V. L. Conley, Assistant District Manager of the Cleveland Sales District, has been transferred to the Pittsburgh District to function as Assistant District Manager in charge of the Buffalo Office.

(Continued on page 468)



THE BILLETEER—BILLET IN PLACE

Mechanical Billet Chipping

By G. W. LENTZ,
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Paper presented at the A. I. & S. E. E. Annual Convention held in Cleveland, Ohio, September 18, 19 and 20, 1934.

In getting up this paper various methods and mechanical means for conditioning billets are referred to purely as an explanatory reference and they must **not** be construed as a reflection on any one individual's efforts along the line of development to produce a successful mechanical billet chipping unit.

Nevertheless with the constant developing of new alloy steels we are adding to the burden of processing, then the consumer comes along with some sort of a wrench to see that all specifications are about as tight as is possible for the money he is paying, not for the wrench, but for the commodity he is buying, all of which adds to the conditioning cost of steel; if he orders 500 tons to-day and wants it yesterday, quite often the neck of the bottle can be found in the billet sheds. The next problem is to get the chippers out on the job, where are they? and are there enough men available to get this order out yesterday; if not, the man in charge gets——if the inspector misses anything in the rush the boss gets — again. Then comes the morale of the chippers themselves; and this has been one of the most perplexing problems of the steel industry for many years, not entirely due to the disposition of the men themselves, but due to the fact that this particular class of work is a most undesirable occupation for a human being to follow. I wonder how many of us here today would like to grind out a livelihood in the same manner that the chippers do; the chances are that the man with the wrench would not get his 500 tons yesterday, or for several days after the promised shipment date.

Fortunately, we do not stop when some one may say "IT can't be done"—instead, we are up and at the problem.

We think, we develop, and we do things; and we always will; thanks to the N. R. A. for not including brains in the code.

Vast amounts of money have been spent in some manner or another endeavoring to develop mechanical means of successfully cleaning billets. In addition to the above, other sums have been spent at the source, or open hearth.

Hammer and Chisel

Some of the old stone age methods of conditioning billets included the use of hammer and chisel.

Cold Cutter

Another method to increase production of billet

cleaning was a cold cutter, with a long handle in the hands of one man, and a sledge hammer in the hands of another. It is safe to assume that a great percentage of steel in those days was returned to the melting pot.

Air Gun Method

The air gun method has undergone many improvements during the years this method has been in use, and chances for further improvement by this means are rather remote.

Draw Cable

Another later improvement was a draw cable attached to an air gun to pull it forward, leaving nothing for the operator to do but start and stop the pulling action of the cable, and steer the air gun to the desired course. This method was quite similar to steering your own automobile while another car would be towing you in.

G. W. LENTZ

Grinding

There seems to be a broad difference of opinion as to just when the grinding was first resorted to. However it is generally conceded that it originated in Sheffield, England, many years ago.

Abrasive Wheels

Laboratories of abrasive wheel makers have made great strides in developing a wheel with a longer life and greater cutting capacity, it revealed that the finer the grain, the slower the cutting, together with a tendency of the wheel to load, particularly on a softer steel surface; the coarse grain wheel naturally will remove more metal; but the life of the latter is much shorter. I have been told that occasionally pieces of abrasive from coarse wheels will embed themselves in the metal. This may not be of much consequence, on the other hand it is not desirable, especially if the bar is rolled into thin sheets.

Slab Milling

Slab Milling as applied to cleaning billets first came to my attention about 18 years ago, and the method is not to be sneezed at, however, it is slow and expensive; slow, for the reason that a milling cutter can only be crowded through steel so fast and no more; as you all know milling cutters teeth are spaced very close together, and spirally arranged, this being a fact we have several teeth of the cutter in contact with the metal at one time; therefore the travel speed is limited. The maintainance of these cutters is very costly, due to frequent grinding and finally discarding the cutter when the diameter becomes too small for further grinding. Another problem of milling billets or slabs is the fact of irregular surfaces as well as the surface defects. Assuming that we have a billet 8" x 8" x 6' with a number of small defects over the entire surface approximately 1/16" deep, and several spots 5/16" or more in depth, you either mill off the 1/16" and chip out the balance by the air gun method. or else go the 5/16" depth and waste the difference. When you get to curved ends or other irregular surfaces you can easily raise the cutter up out of the work, but to go deeper without starting a new cut is another problem. A machine to do milling must be very powerful, and built similar to a heavy duty planer.

Vertical Milling

The vertical milling method is a little like the slab miller, much more expensive, less effective, and with very little productive capacity.

Planer

The Planer method with the conventional clapper box tool holder is more effective than any I have so far described; however, it has some faults. One, is the difficulty of following curved ends caused by hot shearing; another, is to remove short deep defects and at the same time avoid unnecessary loss of metal. The tool should be set at right angle to the surface so that it can be raised or lowered while in contact with the metal it is to cut. Neither can the operator see his work behind the tool, or whether the seam is entirely removed with the first time over; if not, it is then necessary to reverse and go over it a second time.

It is further stated that a tool with a cutting speed of 25 to 35 feet per minute, in continuous contact with certain analyses of steel will overheat before making much progress, thus losing its value. However there are a number of these machines in use at the present time.

Scarfing

While there is considerable scarfing done, it cannot be classed as mechanical; therefore I prefer not to discuss this particular method..

Revolving Head Open Side Cutting Method

We now have the revolving head open side cutting method, better known as the Billeteer, which is among the latest and most successful developments. It possesses almost unlimited flexibility. The cutting head has six different movements, many of them simultaneous, the various movements are as follows;

revolving of the head, up, down, forward, reverse, and laterally. Any one or all of these can be obtained while the head is in motion. The head has a speed of 6-2/3 R.P.M. Either one of the six tools can reach a depth of 3/8" in two seconds. The above speed delivers approximately 40 cutting cycles per minute, each cut 2" wide, the length being governed by the depth of the cut. The unusual flexibility of this unit is principally due to the spacing of the cutter. If the defect is not entirely removed by one tool, the next tool can be lowered so as to complete the removal. The latter action requires less than two seconds, while all other methods require the reversing of the carrier, going back to the starting point for a second cut. Furthermore, this unit carries the lowest tool cost of any known mechanical means of cleaning billets.

Tool Bits

Tool bits are of high speed steel 3/4" x 2" x 8" hardened all over, and ground on the end. No forging, rehardening, or elaborate grinding equipment is necessary. A single tool bit can be taken out by loosening one cap screw. A tool bit and tool holder can be removed by loosening two cap screws. The entire head can be removed by taking out the large centre screw. When necessary to grind tools, they are only ground on the ends. The tool and holder are then placed in a jig and shimmed to a proper length by a combination of various thicknesses, and then replaced in the head. The cutting tips are then all one distance from the centre of the tool head.

Motors

This unit is entirely electrified and self contained, having a total of six motors; 25 horse power for longitudinal travel of carriage, 20 horse power for revolving head, 7½ horse power for raising and lowering cutting head. These three motors are all governed by one master finger-tip control, located to the right of the cutting head. Roll table motor, chucking, and manipulator motors are operated from a drum switch just above the master.

Control Panel

Control panel for the three portable motors is mounted on the carriage. The panel for the three stationary motors are mounted on the base of the machine at the rear near the chuck motor.

Auxiliary Equipment

The auxiliary equipment necessary for this unit consists of the conventional kick off skids, feeding table, and discharging rolls. The billets are brought in from the left and chucked from the sides only. A stop is provided to take the end pressure against the cutting action. When one side is done, the chuck is opened, the manipulator hook is lowered and the billet turned to cut the next side up. In the meantime the chuck again holds it securely. Turning of the billet requires approximately three seconds; when all four sides are finished the billet is rolled out on the right, and another enters from the left, reducing handling time to a minimum. Another important feature is the fact that the operator has a clear vision of his work at all times, either by the ram's horn effect of the chip as it is being cut, or his view of the cut behind the tool.

Electrical Mechanism

The electrical mechanism of this machine is interlocked so as to make it as near fool proof as possible, for instance: the manipulator hook can only be lowered when in the proper position, when the hook is down the carriage cannot be moved in either direction.

Area and Power

Careful and extensive engineering surveys of the air hammer chipping has revealed the average to be eight lineal inches per minute, approximately 13/16" wide, as against 150 square inches per minute by mechanical means.

An extensive survey conducted by a well known engineering company of this city on mechanical chipping, vs. hand chipping methods revealed the startling fact that this unit consumed less power than the air method per ton. I quote a few items as follows covering a given period.

23.73 kilowatt hours	air	
7.48 kilowatt hours	machine	3.17 ratio
19.93 kilowatt hours	air	
7.48 kilowatt hours	machine	2.66 ratio
43.66 kilowatt hours	air	
14.86 kilowatt hours	machine	2.94 ratio

I can further state that since the above test was conducted added improvements will extend these ratios at least 20% more in favor of the machine. This is a safe basis from which to calculate your present cost against the machine method.

In making calls on the steel trade I have been told on a few occasions, "Oh! we don't do any billet chipping, we take care of that at the open hearth." Well, my comments to these remarks were, "We have the best open hearth talent in the world right here in these good old United States, but we still have billet chippers in one form or another."

We are often asked whether pickling is necessary for mechanical cleaning; it is for the old method, and undoubtedly it should be for the new way.

In conclusion, I wish to state that in all sincerity I believe that mechanical chipping is a final, positive, and successful solution to the processing of billets.

Discussion

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Discussion presented by

W. E. Miller, Elec. & Mech. Supt., Bethlehem Steel Company, Johnstown, Pa.

A. J. Standing, Electrical Superintendent, Bethlehem Steel Company, Bethlehem, Pa.

M. J. Conway, Fuel Engineer, Lukens Steel Company, Coatesville, Pa.

G. W. Lentz, Engineer, Bonnot Company, Canton, Ohio.

J. C. Reed, Electrical Engineer, Bethlehem Steel Company, Steelton, Pa.

J. L. Miller, Asst. Chief Engineer, Carnegie Steel Company, Youngstown, Ohio.

W. E. Miller: I want to thank you, Mr. Lentz, for this very interesting paper. The subject of the paper is one of great concern to the steel industry. Considerable money is spent every day for the preparation and reconditioning of billets before they are rolled into the finished product. I think that any man who spends considerable time in the steel plant, or who is intimately connected with it, appreciates the material effect the proper preparation of billets has on the quality of the steel rolled, and the large sum of money that is spent in obtaining these results.

The reconditioning of billets has been a source of heavy expense, I believe, to all the steel companies in the country. I know a lot of time and expense has been spent on the developing of machinery to do more economically and better, the work that is now largely done by hand with the air chipping hammer. In some plants machinery of this type has been successful, while in others it has not. The success or failure of performing this work with machinery depends, I believe, largely on the size of the billets in question. When the size of the billet is down to say, 1-3/4" x 1-3/4" or 2" x 2" or even somewhat larger, it is very questionable to my mind whether the use of mechanical means is economical. These billets usually have but a few spots to be chipped and the labor of setting them up in a machine is usually greater than the labor required to recondition them by hand.

It seems to me there ought to be somebody present who has some ideas on this subject.

A. J. Standing: From the trend of the papers delivered previously, we appreciate the problem facing all plants having merchant mills twenty years old or more and we note with interest the various moves made to improve the product of these mills to meet present day market demands.

The problem of chipping steel is very much alive everywhere and Bethlehem has its phase of this problem to take care of either by hand chipping or by use of some type of reliable and economical billet chipper. To this end we have been trying out one of the Billeteers as described by Mr. G. W. Lentz this afternoon.

While I am not in position to report for the company, I can safely say the machine has been purchased, from which you can draw your own conclusions. I regret that Mr. Lentz is not in position to show the complete machine. I think you would realize from the view of the machine itself that it is a fairly important development.

The flexibility of the machine, as Mr. Lentz said, lies in the adjustment of the head. The head has almost universal movement and the success, as I see it, lies to a large extent in the skill of the operator in manipulating this tool head. In other words, a skilled operator can do about what he wants to do with the head and has sufficient time between cuts to move his machine up and down, forward or across his billet, which gives, as Mr. Lentz pointed out, the advantage of being able to take a small cut in one point, cross your bloom and take a deeper cut, and continue in that cut to a lighter cut. It produces economy in cutting, which as has been pointed out, is not easily obtainable in any other machine.

Another feature we are working out is the proper handling of steel to and from this machine. At the present time the experimental set-up is served by such crane service as is available in the mill. We are proposing to have approach tables and delivery tables so the products to and from the machine can be expedited. I think that, together with a crew of trained operators who are being broken in now, we should materially increase the advantages which we already see possible.

M. J. Conway: I would like Mr. Lentz to describe how he proposes to handle both longitudinal and transverse defects with his machine, and if Mr. Lentz has per cubic inch net costs of removing metal, either in the lower carbon brackets or of alloy steel?

G. W. Lentz: Understand the head revolving at 6-2/3 R.P.M. permits the operator to step the tool across the billet which may be from 6" to 10" before the next tool contacts. The lateral movement is not available while tool is in contact.

M. J. Conway: I am referring to snakes on slabs chiefly, that do not follow any conventional course.

G. W. Lentz: The speed, at which the head travels, allows the operator ample time to move the head laterally in either direction. In this manner, difficult curves of the seams may be easily followed.

Assuming 40 tool cuts per minute ranging from 3" to 5" long x 2" wide and from 1/64" to 3/8" in depth, this is a reasonably fair basis on which to calculate chipping cost with this unit.

J. C. Reed: How many revolutions does the head revolve at?

G. W. Lentz: This question is answered in the above discussion.

J. C. Reed: The piece underneath does not travel along?

G. W. Lentz: No, the billet does not travel but is clamped on top of the rolls which form the base on which the billet rests while it is being cut. The cage is moved back and forth to any position desired.

J. L. Miller: Is that machine in general use?

G. W. Lentz: Yes sir.

J. C. Reed: Where are these machines in use?

G. W. Lentz: We have one of them installed in your Lehigh plant which has been in commercial operation for approximately four months.

PERSONNEL CHANGES

(Continued from page 463)

Assisting Mr. Conley will be A. W. Bryant, with headquarters at Rochester, New York.

At a meeting of the board of directors of the General Electric Company on October 26, 1934, in the offices of the company at 570 Lexington Avenue, New York City, Francis D. Bartow was elected a member of the board.

F. R. Kohnstamm, widely known within the electrical industry, has been appointed Manager of the Lighting Division of the Westinghouse Electric and Manufacturing Company, according to an announcement made by President F. A. Merrick. In his new position, Mr. Kohnstamm will have supervision over all lighting activities, including sales, engineering and manufacturing, now conducted at the Westinghouse Cleveland Works, in Edgewater Park. Until his appointment, he was Sales Promotion Manager of the Company, with headquarters at East Pittsburgh, Pa.

Russell L. Van Cleve has been appointed manager of blast furnace products, coke by-products, and scrap purchases, for Carnegie Steel Co., Pittsburgh, succeeding Thomas Woods, who recently resigned under the operation of the Carnegie retirement plan.

James M. Darbaker, master mechanic of the Gary, Ind., sheet mill of American Sheet & Tin Plate Co. for the past two years, has been named general manager of the plant, succeeding John A. Gross, who will enter a specialized sales field for the company. Mr. Gross has been active in the steel production field since 1890.

K. C. Gardner, vice president in charge of machinery sales for United Engineering & Foundry Co., Pittsburgh, has had his duties extended to include the sale of all the products made by the United company. Mr. Gardner's new title is vice president in charge of sales.

Horace Mager, formerly in the roll sales department for the company, now supervises the roll and steel casting sales division.

NEWS OF THE INDUSTRY

The Carnegie Steel Company has placed an order with the United Engineering & Foundry Co., Pittsburgh for a continuous hot strip mill consisting of 10 horizontal stands, two high and four high stands, two vertical edgers and one scale breaker to be installed at the McDonald Ohio works of Carnegie. This mill with an annual tonnage of approximately 400,000 tons of hot-rolled strip is expected to be installed and in operation in the third quarter of 1935. It will produce strip steel in cut lengths and coils up to 38" wide and down to 16 gauge as well as down to 18 gauge in widths up to 24". Complete facilities for pack annealing, slitting, oiling and pickling cut lengths are to be included in the new rolling unit.

Contracts have been awarded for erecting the Youngstown Sheet & Tube Company's new cold rolling mill at Campbell, it was announced by Frank Purnell, president of the company.

The mill contract was awarded to the Mesta Machine Co. of Pittsburgh, and the steel will be erected by the Fort Pitt Bridge Co., of Pittsburgh.

The new cold rolling mill, with a capacity of from 200,000 to 250,000 tons a year, will absorb a part of the production of the new continuous strip mill now being erected by the company at Campbell, which will have an annual capacity of from 500,000 to 600,000 tons of hot rolled strip. The cold mill will finish strip into sheets for automobile and other purposes.

A separate building covering 216,000 square feet will house the cold rolling mill equipment. The latter will include one 3-stand tandem 4-high finishing unit, and two single-stand 4-high mills, along with continuous annealing, pickling, shearing, and straightening machinery.

The cold mills will be capable of rolling down the unfinished hot strip to 26 gauge in thickness and 84 inches in width.

The cold rolling mill is expected to be ready for operation by April 1. The continuous mill will probably be completed by February 1.

ASSOCIATION NOTES

COMING MEETINGS AND PAPERS

Philadelphia Section

L. F. Coffin, Chairman L. O. Morrow, Secretary
Engineers Club, 1317 Spruce Street
Dinner 6:00 P. M. Meeting 7:00 P. M
December 1, 1934

"The Automatic Control and Use of Blast Furnace Gas in Steel Mill Furnaces" by A. J. Fisher, Fuel Engineer, Bethlehem Steel Company, Sparrows Point, Md.

A story of the making, using and controlling of Blast Furnace Gas.

Mr. Fisher in his paper, will give the physical, chemical, metallurgical, and combustion sides of the Steel Mill problems in connection with the automatic control and use of blast furnace gas in steel mill furnaces.

OBITUARY

Franklin M. Bowman, Vice-President of the Blaw-Knox Company, Pittsburgh, Pa. died suddenly on October 12th at his home in Pittsburgh, Pa. He was in his sixty-fifth year.

In his capacity as Vice-President of the Blaw-Knox Company, Mr. Bowman was in charge of the Transmission Tower and Structural Steel Divisions of the Company. He was actively identified with transmission line design and erection of international significance and the construction of some of the largest mills in the country.